CHAPTER 4 ELECTRICITY DEMAND FORECAST

4.1 Evolution of Armenian GDP

During the past four years, Armenia has undergone substantial structural changes in its economy. An increasing share of services and corresponding reduction in the relative size of the goods sector is a primary feature of the country's present economic development.

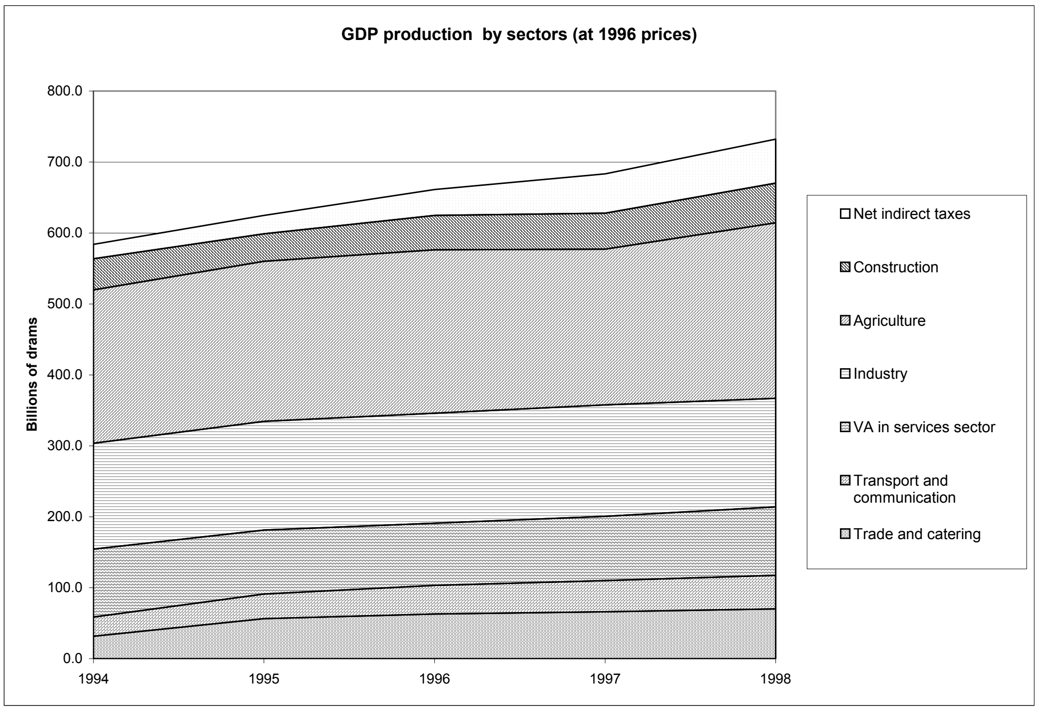


Figure 1. Structure of GDP: 1994 – 1998.

In 1994-1998, official statistics registered high growth rates in all sectors of the economy except for industry, with the highest rates of growth in construction, transport and trade. The average growth rates for 1994-1998 reached 5.8% for total GDP (at constant 1996 prices), of which total services grew 8.5 percent, transport and communication 15.16 percent, and trade 21.9 percent. Construction and agriculture also exhibited moderate performance at 6.32 percent and 3.45 percent growth, respectively, while industry remained practically at the same level, exhibiting only 0.6 percent growth. The annual performance of the economy as a whole was quite uneven, showing the highest growth of 7.1 percent in 1998 and the lowest, 3.3 percent, in 1997. These figures are all illustrated in Table 1.

Table 1 -- Production of GDP (Billions of 1996 drams)

	1994	1995	1996	1997	1998
GDP (at constant prices of 1996)	584.0	624.7	661.2	683.2	732.1
Net indirect taxes	20.3	25.7	36.5	55.2	61.7
Total value added	563.7	598.9	624.7	627.9	670.4
Value Added in Goods Sector	409.2	417.7	433.6	427.2	456.4
Of which:					
Industry	149.3	153.2	154.9	156.9	152.8
Agriculture	216.0	225.6	230.1	219.7	247.5
Construction	43.9	38.9	48.7	50.6	56.1
Value Added in Services	154.5	181.3	191.1	200.7	214.0
Transport and Communication	27.1	34.5	40.3	44.0	47.5
Trade and Catering	31.8	56.4	63.0	66.1	70.1

Source: Armenia Economic Trends, Quarterly Issue, July – September 1999.

The result of these structural changes may be attributed to the changing structure of GDP production. The combined share of industry and agriculture, which jointly generated almost two thirds of GDP in 1994, dropped by 1998 to 54.7 percent (see Table 2), while the relative shares of transport and trade increased by 2.0 percent and 4.2 percent, respectively.

It should be noted that these growth figures are somewhat subjective in the absense of an accurate assessment of the size of the Armenian parallel economy. However, this assessment is outside the scope of this study; therefore, the official statistics are used exclusively.

Table 2 - Composition and changes of GDP by main sectors

	1994	1995	1996	1997	1998
% of total GDP at current prices					
GDP at market prices	100.0	100.0	100.0	100.0	100,0
Net indirect taxes	3.1	3.7	5.5	8.0	9,2
Value added	96.9	96.3	94.5	92.0	90,8
Industry	29.1	24.3	23.4	22.5	20,4
Agriculture	43.5	38.7	34.8	29.4	29,8
Construction	6.7	8.5	7.4	8.1	8,5
Transport and communications	4.2	4.3	6.1	7.5	7,1
Trade	4.5	9.5	9.5	9.0	8,6
Others	8.9	10.9	13.3	15.5	16,4
% of total GDP at 1996 constant prices					
GDP at market prices	100.0	100.0	100.0	100.0	100,0
Net indirect taxes	3.5	4.1	5.5	8.1	8,4
Value added	96.5	95.9	94.5	91.9	91,6
Industry	25.6	24.5	23.4	23.0	20,9
Agriculture	37.0	36.1	34.8	32.2	33,8
Construction	7.5	6.2	7.4	7.4	7,7
Transport and communications	4.6	5.5	6.1	6.4	6,5
Trade	5.4	9.0	9.5	9.7	9,6
Others	16.4	14.5	13.3	13.3	13,2
Year on year %					
GDP at market prices	5.4	7.0	5.8	3.3	7.2
Net indirect taxes	-10.2	26.9	41.6	51.5	11.6
Value added	6.2	6.2	4.3	0.5	6.8
Industry	10.3	2.6	1.1	1.3	-2.6
Agriculture	2.9	4.4	2.0	-4.5	12.6
Construction	5.7	-11.4	25.2	3.9	11.0
Transport and communications	-3.8	27.0	16.8	9.2	8.0
Trade	60.4	77.6	11.6	5.0	6.1
Others	8.1	-5.5	-2.8	3.2	6.3

Source: Armenia Economic Trends, Quarterly Issue, July – September 1999.

4.2 GDP by expenditures

GDP categorization by expenditure types is presented in Table 3. The value of net exports is negative, exceeding capital investments, changes in inventories, and public consumption taken together, in each year since 1994. The share of the last remains at a stable level throughout this period. During 1995-1998, the share of GDP spent for fixed capital formation dropped in comparison with 1994 from 20 percent to around 16 percent.

Table 3 -- Use of GDP (millions of drams)

	1994	1995	1996	1997	1998
GDP (at current market prices)	187 065	522 256	661 209	804 336	958 791
Final consumption	197 972	613 392	738 267	922 872	1 069 931
Of which:					
- Private consumption	176 885	545 056	664 002	832 652	962 611
- Public consumption	21 087	68 336	74 265	90 220	107 320
Gross fixed capital formation	37 855	84 364	118 254	130 336	164 881
Changes in inventories	6 012	11 859	14 029	23 015	16 903
Net exports	-63 177	-199 810	-216 543	-305 670	-317 734
Discrepancy	8 403	12 451	7 202	33 783	24 807
Use of GDP (% of GDP)					
Final consumption:	105.8	117.5	111.7	114.7	111.6
- Private consumption	94.6	104.4	100.4	103.5	100.4
- Public consumption	11.3	13.1	11.2	11.2	11.2
Gross fixed capital formation	20.2	16.2	17.9	16.2	17.2
Changes in inventories	3.2	2.3	2.1	2.9	1.8
Net exports	-33.8	-38.3	-32.7	-38.0	-33.1
Discrepancy	4.5	2.4	1.1	4.2	2.6
Current Account (% of GDP)	-35.9	-37.5	-29.7	-27.8	-27.1
Foreign debt (% of GDP)	31.0	29.0	32.5	39.1	38.9

Source: Armenia Economic Trends, Quarterly Issue, July – September 1999.

It is interesting to note that, on average, private consumption approximately corresponds to Gross Domestic Product; in other words, domestic production has been able to provide for private consumption only. The country has been relying heavily upon foreign resources to finance its development during the period under consideration. Consequently, the level of accumulated debt reached 38.9 percent of GDP by the end of 1998.

At the same time, the rate of general economic development was moderate. Though the current account deficit was reduced from 35 to 27 percent of GDP, it remains at a high level, leading to continued expansion of external debt for the foreseeable future.

On the other hand, the statistics indicate that a relatively moderate rate of economic development was achieved, mainly due to foreign resources financing local investments. Gross domestic production barely covered final consumption. An analysis of general economic indicators indicates that during the period of 1994-1998, the country did not develop its own export capabilities, since the only growth observed was in the services sector, which is unrelated to export activities. Therefore, the funding of new investments through foreign sources may become a problem in the future, while even relatively moderate growth rates of 5.2 percent (the average weighted rate for 1994-1999, also taking into account the economic slow down to 3 percent experienced in 1999) should be considered problematic. These aspects of the Armenian economy render any electric power consumption forecast subject to a high degree of uncertainty.

4.3 Historic trends in electricity consumption

The moderate economic growth demonstrated by the country in recent years has been accompanied by a correspnding reduction of electricity consumption, as illustrated in Table 4. Between 1997 and 1999, gross electricity generation dropped by 6.4 percent. The relative growth of this value in 1998 is attributable mainly to an increase in net exports of electricity. At the same times gross domestic consumption of electricity in 1999 declined even further; relative to 1997, this reduction amounted to 10.4 percent.

Two factors contributed to this sharp decline: the first is a decline in final consumption; the second is a reduction of technical and commercial losses.

Table 4 -- Recent trends in electricity consumption

		1997	1998	1999	2000
Gross generation*	GWh	6021	6140	5634	5674**
Gross export***	GWh	53	223	287	N/a
Net Export	GWh	49	206	N/a	N/a
Gross Domestic Consumption	GWh	5968	5917	5347	5280**
Gross Domestic Peak****	MW	1381	1178	1071	N/a

*) Gross generation includes auxiliary consumption of generators.

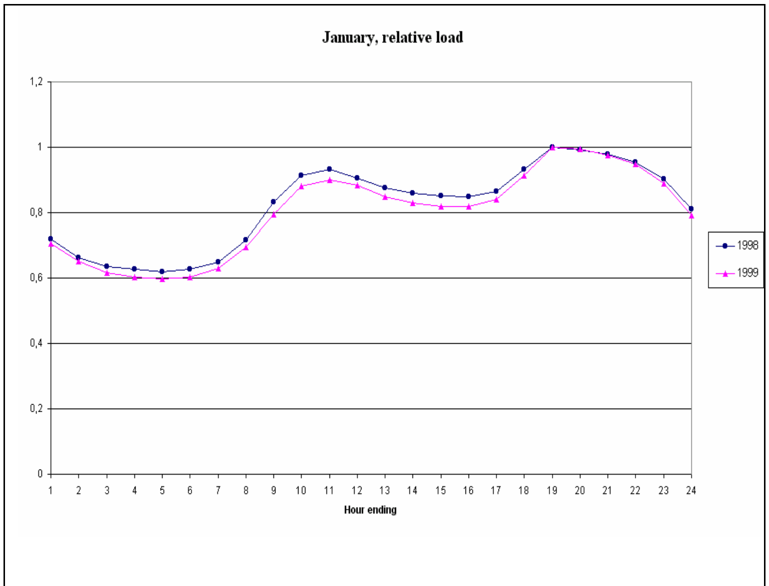
**) These projected values for generation and consumption of electricity were used by Energy Regulatory Commission of Republic of Armenia to calculate tariffs for a year 2000.

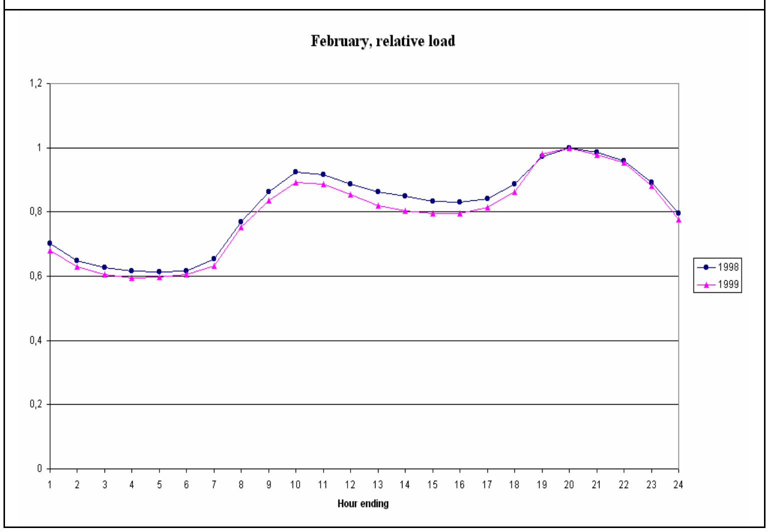
***) Gross export of electricity was calculated on the base of net export assuming 7.7% losses in high voltage transmission grid.

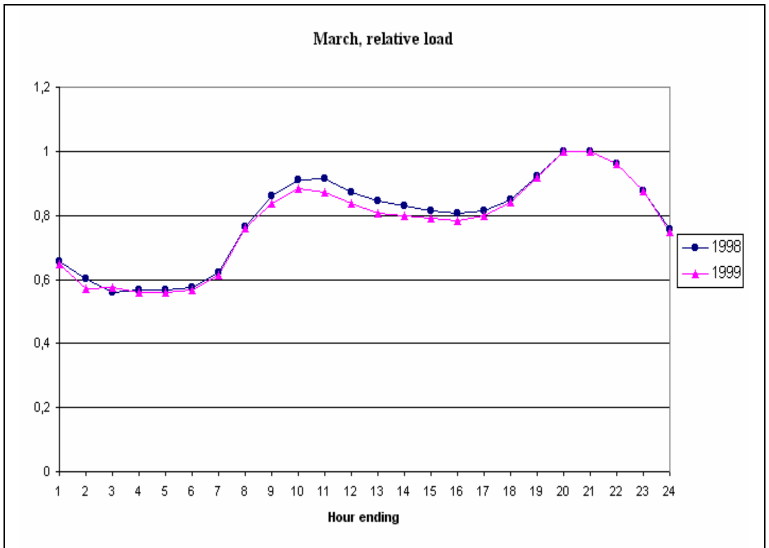
****) Domestic peak loads were retrieved from actual hourly dispatch data for the corresponding year.

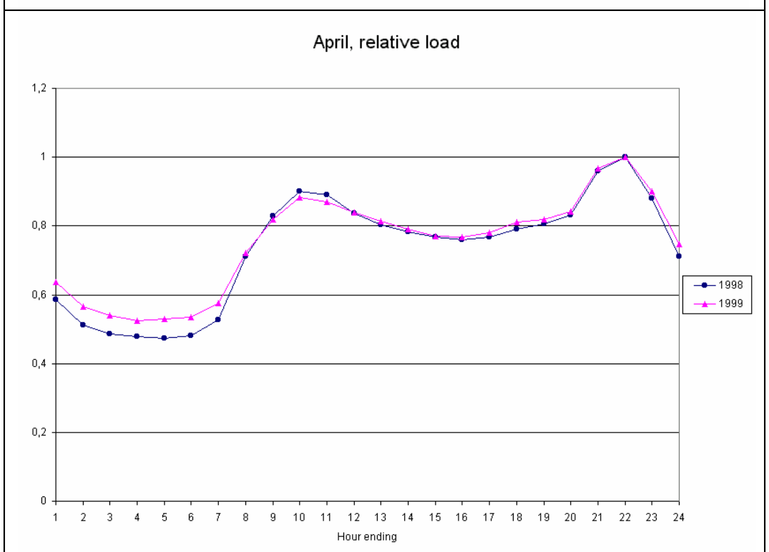
It is noteworthy that, despite the severe drop in the amount of consumed electricity, the consumption pattern remained stable over the period under consideration. Typical hourly load curves, by month, are presented in Table 5. These were derived from average hourly loads, based on actual hourly dispatch data for 1998 and 1999. These loads were then unitized by dividing each hourly value by the maximum daily consumption, so that the hourly values would vary between 0 and 1. Such a transformation allows for easier comparisons of load shapes, regardless of the values of maximum load.

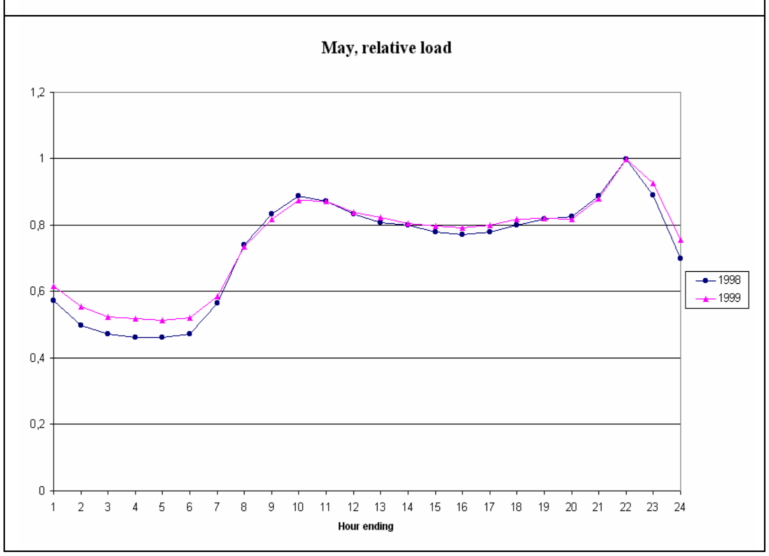
Table 5 -- Typical load curves for 1998 and 1999 years.






March, relative load
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour ending
1998
1999


April, relative load
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour ending
1998
1999


May, relative load
1,2
1
0,8
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0,4
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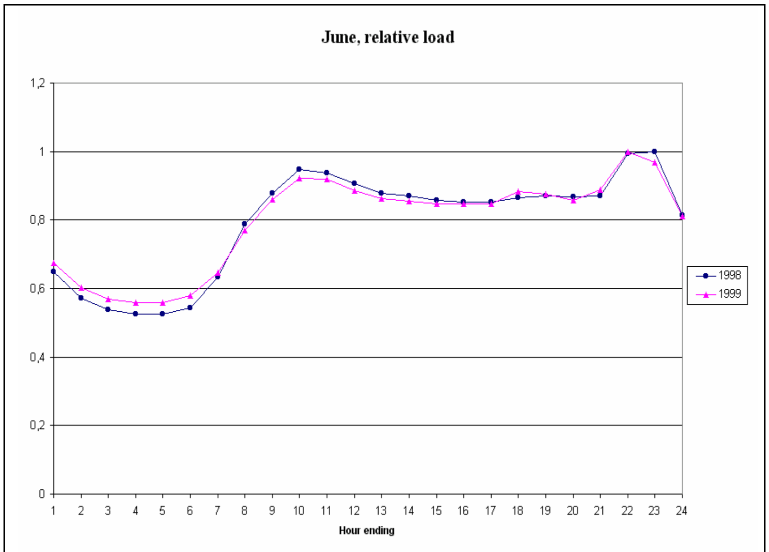
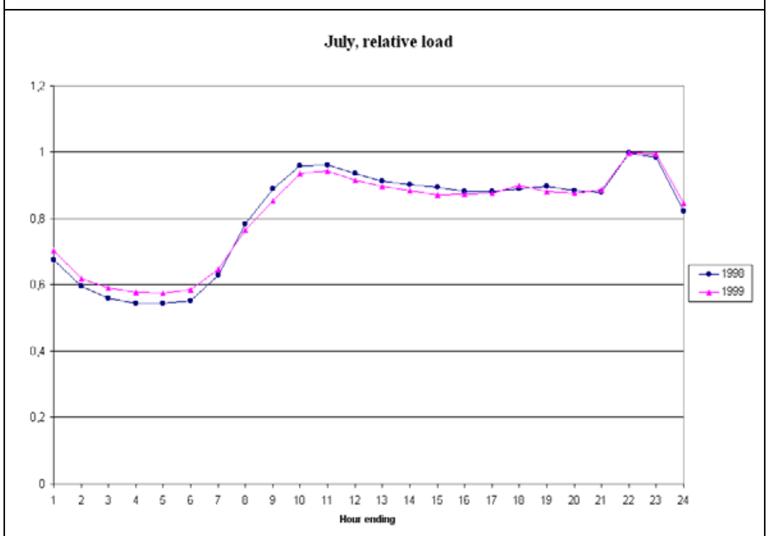
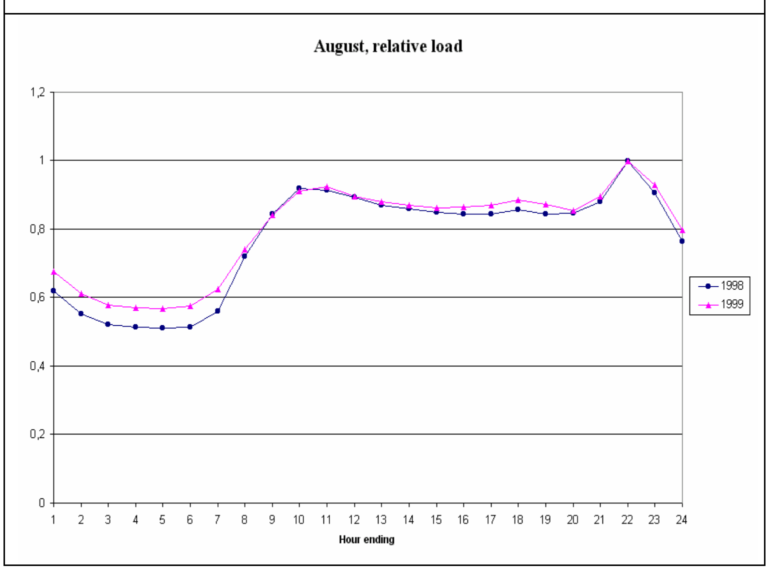
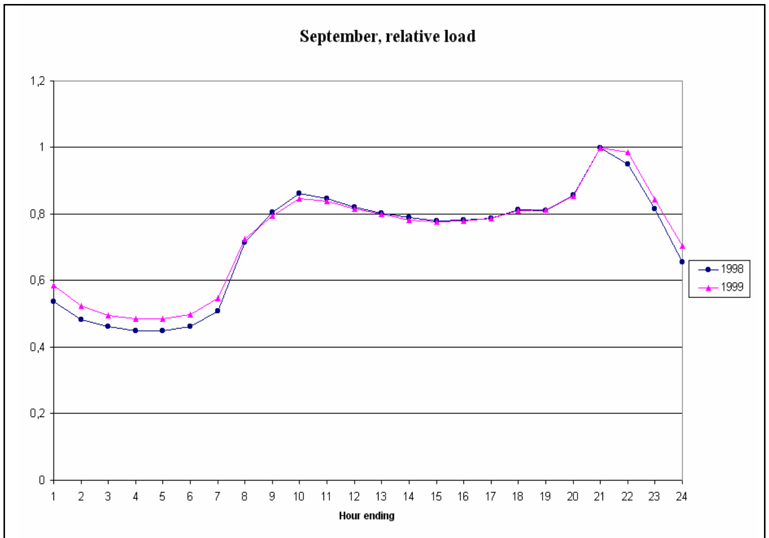
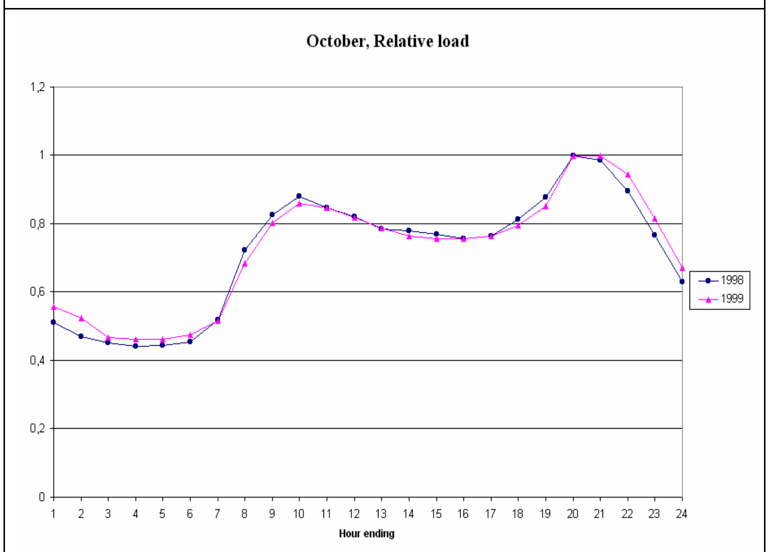
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour ending
1998
1999

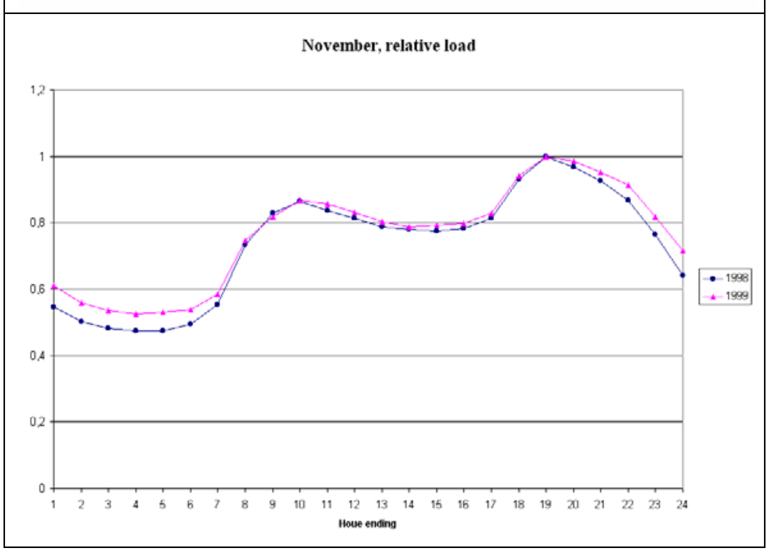

June, relative load
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour ending
1998
1999

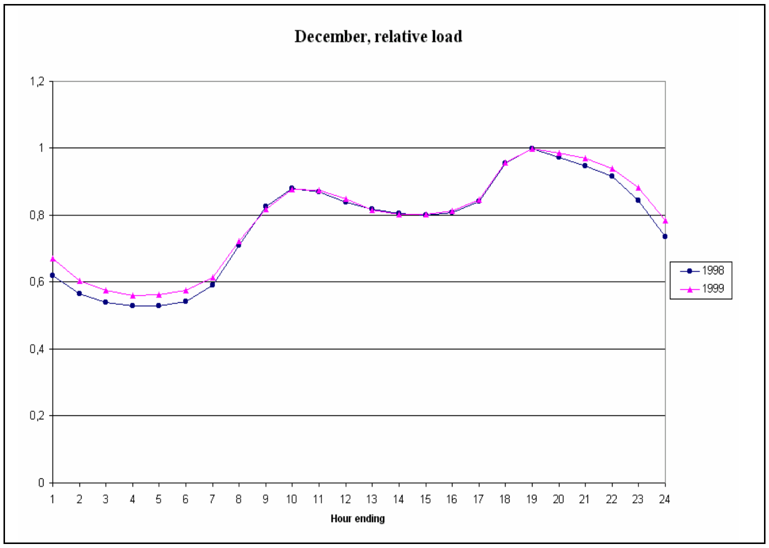

July, relative load
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour ending
1998
1999


August, relative load
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour ending
1998
1999


September, relative load
1998
1999
Hour ending


October, Relative load
1998
1999
Hour ending


November, relative load
1998
1999
Houe ending



Several conclusions can be drawn from Table 5. For January, February and March the 1999 curves are slightly lower during the day, with the exception of the peak hour. During these months the average actual loads in 1998 were approximately 80-200 MW higher than in 1999. Because the base load in 1998 was higher, the load factor for these months in 1998 was higher, which in turn means that the relative daily variation for 1999 is higher. The general picture changes beginning with April. From that point through the rest of the year, the daily load curves closely resemble each other from 8 a.m. till approximately 20 p.m. The remainder of the time, loads in 1999 are higher than in 1998. Larger nighttime consumption in 1999 can be explained by the extremely dry conditions in that year, which resulted in higher irrigation loads than in the previous year (irrigation pumps tend to operate continually over a 24 hour period).

4.4 Review of forecasts done by other research groups

A number of forecasts of electricity consumption have been developed by different international organizations. They differ both by applied methodologies and by results. The summary of projections is presented in Table 6.

Table 6 -- Forecasts developed by different organizations

The World Bank Electricity Demand Projection (WB 1993)								
Year	**1990**	**1994**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
Total Consumption (GWh)	9021	7280	7252	8366	9651	11134		
LAHMEYER INTERNATIONAL (1994)								
Year	**1990**	**1994**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
Base scenario								
Electricity Consumption (GWh)	9745	8975	4486	5588	7175	9263		
Low scenario								
Electricity Consumption (GWh)	9745	8975	3971	4530	5012	5603		
High scenario								
Electricity Consumption (GWh)	9745	8975	4539	6128	8008	10523		
LAHMEYER INTERNATIONAL (1996)								
Year	**1988**	**1991**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
High case								
Electricity Consumption (GWh)		9750	3054	5990	8120	11770		
Medium case								
Electricity Consumption (GWh)		9750	3054	5830	7420	9490		
Low case								
Electricity Consumption (GWh)		9750	3054	5520	6620	7990		
Ministry of Energy (1999)								
Year	**1988**	**1991**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
Electricity Consumption (GWh)				5250	7420	9500	10300	11100
Generation (GWh)				6700	9070	11140	12600	13600
Peak Load (MW)				1300	1590	1800	2100	2200

Summarizing the results for the year 2000 results in a forecast range of 4530-6700 GWh, which was supposed to represent boundaries for final electric power consumption for this year. The upper limit would be even higher with the inclusion of the 1993 World Bank projections, although these values were not considered due to the fact that this forecast was developed before the economic crisis of 1994 reached its full scale.

Unfortunately, not all the forecasts presented data on peak demand; therefore, it is difficult to judge how far or close they eventually deviate from reality for this indicator. Of all the projections considered in the table the most accurate is Scenario B by *LAHMEYER INTERNATIONAL (1994)*. It is interesting to observe that the forecasts developed two years later by the same organization, denoted at the table as *LAHMEYER INTERNATIONAL (1996)*, should have been more close to reality, but were actually less accurate.

All forecasts substantially overestimated consumption of electric power; actual values do not fall into any of the projected intervals. Unfortunately, these forecasts did not present projections for 1999. However, it is reasonable to compare projections for the year 2000 with actual indicators for 1999. Total metered final consumption in 1999 amounted to 3,600 GWh; the difference between this actual and the forecasted 2000 value thus approaches 26 percent. However, if this comparison is based on real consumption, which consists of metered sales plus commercial losses (equaling approximately 4,300 GWh), then the discrepancy would not be as substantial. On the other hand, no one had foreseen such large commercial losses at the time the forecasts were developed.

The most substantial parameter affecting future levels of electricity consumption is the rate of economic development. However, the assumptions of economic growth were not so far from the observed economic performance. The level of GDP used in LAHMEYER INTERNATIONAL (1996) corresponds very closely to actual production of GDP. Table 7 summarizes differences between assumptions and actual economic performance.

Table 7 -- Basic assumptions for electricity consumption forecasts.

Year	Actual for 1998 (current prices)	Actual for 1998 (constant prices of 1996)*	*LAHMEYER INTERNATIONAL 1996*			
			1995	**2000**	**2005**	**2010**
High case						
GDP (mln US $ 1995)	1899**		1336	1918	2818	4141
Structure of GDP production						
industry and transport	30%	30%		54%	50%	48%
Services	28%	25%		18%	24%	32%
Construction	9%	8%		10%	12%	10%
Agriculture	33%	37%		18%	14%	10%
Medium case						
GDP (mln US $ 1995)	1899**		1336	1831	2450	3278
Structure of GDP production						
industry and transport	30%	30%		52%	47%	49%
Services	28%	25%		20%	24%	25%
Construction	9%	8%		3%	4%	6%
Agriculture	33%	37%		25%	25%	20%
Low case						
GDP (mln US $ 1995)	1899**		1336	1665	2026	2465
Structure of GDP production						
industry and transport	30%	30%		52%	48%	48%
Services	28%	25%		18%	24%	32%
Construction	9%	8%		10%	12%	10%
Agriculture	33%	37%		20%	16%	10%

Source: *LAHMEYER INTERNATIONAL 1996,* calculated using data from Table 3.

*) To achieve comparable results with assumptions on the structure of GDP the data from Table 3 were rearranged in the following way: share of transport and communications was added to industry, trade and other services were considered as services, agriculture and construction remained unchanged, results of such transformation were divided by the total share of Value Added.

**) Actual GDP for 1998 year was calculated from value of GDP in current drams (Table 3) and average exchange rate 504,8 Dram/$ for 1998.

The error between the medium case GDP projections for 2000 and the actual value of GDP in 1998, is small -- less than 4 percent, which can be considered a very good estimate. Instead, it is the inaccurate assumptions about the relative proportions of industry and transport that caused the dramatic deviations between projected energy consumption and the actual values.

According to the medium case forecast, total electric energy consumption should have been around 5830 GWh. This is even higher than current gross generation, which includes auxiliary consumption of generators, all types of losses, and non-payments. A direct comparison of the projected 5830 GWh with total metered sales of 3600 GWh to final consumers in 2000 gives an almost 62 percent difference, which presents a good indication of the overall level of accuracy of these forecasts.

The 1999 forecast by the Ministry of Energy is the second most accurate projection. This can be explained by the fact that it was developed just a year ago. However, its deviation from actual final electricity consumption also reaches about 46 percent.

4.5 Methodology of forecasting

The forecasting procedure employed for this study, along with the set of models for various segments of the market, are presented in Figure 2.

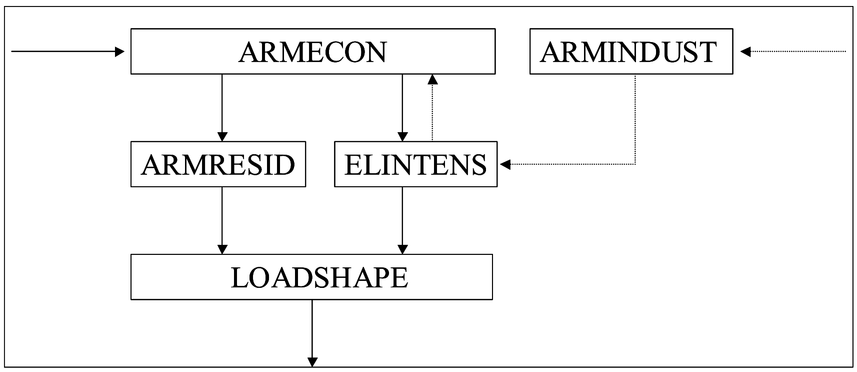


Fig. 2. System of models for projecting electricity consumption in Armenia.

A summary of each of these models follows:

ARMECON - this econometric model was built to estimate rates of economic growth as well as the structure of GDP production, based on assumptions on future policy with regard to rates of accumulation and borrowings. The output of this model is used as economic activity input in other modules.

ARMINDUST – initially, this model was intended to take into account future industrial development along with other sectors of the economy in the ARMECON module. However, an analysis of the evolution of GDP production indicates that during 1994-1998, no sustainable industrial development occurred in real terms. Therefore, it is not possible to derive any correlation between investments and level of industrial growth during this time period. For that reason, it was decided to treat industry separately from the rest of the economy, and for different scenarios to make separate assumptions of future industrial growth. Thus, the rate of industrial development does not depend upon the amount of total investments in any particular year. On the other hand, industrial production is taken into account for the calculation of total GDP. Different assumptions are also made about changes in industrial electricity intensity that is related to the rate of industrial growth. This is presented in the diagram by a set of dashed arrows.

ELINTENS – this module was developed to calculate electricity intensities for separate sectors of the economy, to trace historical changes caused by variations in production levels, and to calculate energy consumption on the basis of indicators of economic activity and electricity intensity in each sector.

ARMRESID – this module was developed to take into account possible changes in residential sector consumption patterns caused by changes in economic conditions and the possible restoration of natural gas supplies. Since the share of electricity consumption in households currently exceeds 40 percent of total metered sales, which is twice the consumption of electric power in industry, it is necessary to conduct a detailed analysis of energy uses in this sector.

LOADSHAPE – this module was built to simulate future changes in the total system load curve caused by the uneven development of different sectors of the economy and alterations of consumption patterns inside the various sectors themselves.

Overall forecast results are expressed as annual values of consumed electric power, the corresponding required amounts of generation to satisfy this demand, and monthly values of system peak loads. More detailed descriptions of each component is contained in the following sections.

4.5.1 ARMECON – model for projecting Armenian economy

ARMECON is an econometric model developed to estimate rates of economic growth. The model consists of two blocks:

- Production of GDP by economic sector (10 equations);
- GDP by expenditure type (9 equations).

All model parameters were estimated statistically based on a time series analysis of the period from 1994 through 1998.

As a rule, very limited time series analyses do not allow building complex equations. In this case, equations with only one or two factors were included. Nonetheless, in all cases the observed correlation between input and output variables was very strong. Factors included in each equation in every block are shown in Tables 8 and 9. A special equation for public utility services was introduced into the block dealing with GDP to take into account the electricity consumption for the potable water supply that makes up a substantial share of electricity consumption for Armenia.

Table 8 -- GDP by expenditures: structure of equations

	GDP	Total final consumption	Households	Institutions	Gross savings	Gross Fixed Capital Investments	Changes in Goods & Products Stock	Net Import of Goods & Services	Flow of Debt	Flow of additional resources
GDP	+									
Total final consumption		+	+	+						
Households	+			+	+			+		
Institutions	+			+						
Gross savings						+	+			
Gross fixed capital investments	+					+ Exog.				
Changes in goods & products stock	+						+			
Net import of goods & services								+	+	+
Flow of debt									+	

									Exog.	
Flow of additional resources										+ Exog.

Table 9 -- GDP production by sectors: structure of the module

	Industry	Construction	Agriculture	Total services	Transport and communications	Trade	Public Utility Services	Total value added	Net Indirect Taxes	**GDP by Sector**	Final consumption	Households consumption	Gross fixed capital investments	Flow of additional resources
Industry	+ Exog.													
Construction		+											+	+
Agriculture			+										+	+
Total services				+							+		+	
Transport and communications		+			+			+						
Trade				+		+					+			
Public Utility Services							+					+	+	
Total value added	+	+	+	+	+	+	+	+						
Net Indirect Taxes								+	+					
GDP by Sector								+	+	+				

The principal input to the model is the rate of savings, which determines the amount of gross fixed capital formation as a percent of GDP. Apart from this variable, there are two other parameters that play an extremely important role: the flow of debt and the flow of capital additional resources.

Additional capital resources are defined as the annual difference between net exports of goods and services, and the flow of debt. These two values actually determine the amount of resources available for the country’s investment.

It should be mentioned that during the most recent four years, the value of additional resources many times exceeded the amount that country officially borrowed from international donor organizations. Therefore, the economy of Armenia heavily depends upon foreign resources and the pace of future development to a very large extent is determined by their availability.

Table 10 presents estimates of additional resources in real terms. Their value for each year was calculated by subtracting the flow of debt from net imports of goods and services. Data on external debt were taken from official information provided by the Ministry of Statistics and the Ministry of Finance. In essence, additional resources represent all other sources of financing apart from official borrowings. They include official donations that Armenia received for this time period as well as private transfers from abroad. This flow is more than double the official borrowings, which stresses its importance.

Table 10 -- GDP by expenditures in constant Drams of 1996

		1994	1995	1996	1997	1998
Total final consumption	mln Drams	618051	733712	738369	783884	816742
Households	mln Drams	552219	651972	664093	707252	734818
Institutions	mln Drams	65832	81740	74275	76633	81924
Gross savings	mln Drams	136949	115098	132301	130256	138767
Gross Fixed Capital Investments	mln Drams	118180	100913	118270	110707	125863
Changes in Goods & Products Stock	mln Drams	18769	14185	14031	19549	12903
Net Import of Goods & Services	mln Drams	197233	239003	216573	259635	242545
GDP	mln Drams	584000	624700	661300	683200	731900
Flow of Debt	mln Drams	0	57462	75891	73581	61763
Flow of Additional resources	mln Drams	197233	181541	140682	186054	180782
Additional resources as % of GDP	%	33,8%	29,1%	21,3%	27,2%	24,7%

Source: calculated on the basis of table 3.

GDP for the current year is estimated on the basis of the amount of gross fixed capital formation and the level of GDP for the previous year. Next, total final consumption in households and institutions, changes in goods and products stock, and net imports of goods and services are estimated.

Variables that are marked “exog.” in Tables 8 and 9 are independent parameters for the module. They represent future economic policy and are input into the module as exogenous variables. Varying assumptions are made regarding their respective values in order to develop specific scenarios of economic development. The module therefore provides a feasibility check of different rates of economic development and structural changes.

The model also explicitly accounts for tradeoffs between current consumption and savings. In other words, the higher the final consumption of GDP in any particular year, the less resources are available for investments, other things being equal. In turn, investments along with current levels of GDP determine future growth rates. Thus, current consumption can be increased at the expense of future economic growth.

As mentioned previously, because of the absence of the relationship between the amount of investment and the rate of growth in industry, this sector was excluded from the model. In other words, industrial development does not depend on investments in the ARMECON module.

This bears two important economic consequences. First, in order to achieve projected economic growth in reality, higher levels of investment than is considered in the module may be required. Second, it is impossible to assess the level of direct investment required to reach specific rates of industrial development.

Finally, it should be noted that this model reproduces relationships of economic variables monitored in 1994-1998. Its application for projecting the magnitude of economic growth through 2015 for a country undergoing a transitional process introduces a significant level of uncertainty into the planning process. 4.5.2 ELINTENS: module to estimate energy consumption

The ELINTENS module was developed to calculate electricity consumption by economic sector, excluding residential consumption. The residential sector is modeled separately because it is fundamentally different than the other sectors, and its simulation correspondingly differs in terms of methodology.

ELINTENS deals with three crucial factors that substantially affect electricity consumption:

- economic growth by sector;
- electricity usage intensity by sector;
- changing electricity prices.

Auxiliary consumption of generators as well as technical and commercial losses are taken into account in this module. These three additional exogenous parameters are introduced into this module to derive total generation of electric power from final consumption estimates. The impacts of the first two variables are fairly straightforward, with an assumed value being added to the final consumption level.

Impacts of the change in commercial losses pose something of a problem. On the one hand, a reduction in commercial losses could lead to the growth of final consumption and therefore increase required generation. Such a hypothesis is based on the assumption that major commercial losses are caused by activities of commercially viable consumers which are capable of paying for electricity, but do not do so because payment discipline is absent. On the other hand, the consequences of reduced commercial losses could be quite the opposite -- a reduction in the amount of stolen electricity may act to reduce total consumption. The latter is the case when consumers causing so-called commercial losses are actually incapable of paying for "lost" electricity. It was assumed in the forecast that the major portion of present commercial losses will eventually turn into payable demand. A specific rate of reduction of technical losses was assumed in the calculations.

Electricity intensities, which bear an important role in the determination of electric power consumption, are also affected by many factors. Among them are the production technologies employed by going concerns as well as the respective levels of production capacity usage. For the current planning process, the main focus was on the latter factor.

Table 11 presents historical data on consumption of electric energy by different customer categories, which in turn were used to calculate electricity intensities.

Table 11 -- Metered Electricity Consumption by Sectors

	1997		1st half 1998*		1998**		1999	
	GWh	%	GWh	%	GWh	%	GWh	%
Residential sector	1405,4	39,2%	766,4	42,9%	1482	40,5%	1475	38,5%
Industry	722,4	20,2%	312,2	17,5%	604	16,5%	748	19,5%
Budget Organizations	333,9	9,3%	154,5	8,6%	*252****	6,9%	229	6,0%
Irrigation	243,7	6,8%	104,9	5,9%	*456****	12,4%	456	11,9%
Drinking Water	298,9	8,3%	150,7	8,4%	291	8,0%	300	7,8%
Transportation	151,3	4,2%	80,2	4,5%	155	4,2%	191	5,0%
Others	376,6	10,5%	98,1	5,5%	190	5,2%	200	5,2%
Net Exports	49	1,4%	120,8	6,8%	234	6,4%	234	6,1%
Total	3581,2	100%	1787,8	100%	3458,0	100%	3833,2	100%

Source: Ministry of Energy.

Note: "Others" includes electricity usage in commercial sector, street lighting, etc.
*) Information on the whole 1998 was presented by Ministry of Energy in Government of Armenia- Power Sector Energy and Financial Report. It included residential customers, budget organization and other consumers.
**) Information on first 6 months of 1998 covered all categories of customers. To obtain data for the whole 1998 a half-year data were inflated in proportion to share of generation during first 6 months of 1997, which constituted 57% of annual generation.

***) Before 1998 electricity consumption of municipal irrigation systems was accounted as consumption of budget organization. After 1998 it has been transferred to the consumption of irrigation system, therefore one can observe a sharp drop in consumption of budget organization against steep increase in consumption of irrigation over a very short period of time.

It is practically impossible to derive any sustainable trends for electricity consumption from Table 11, primarily due to very limited time series of data. Even the data for 1998 were extrapolated from the indicators for only the first half of the year. In addition, some changes in the system of consumption classification were introduced in 1998 (see ***), which impedes a direct inter-temporary comparison. The only thing that can be stated with a high level of certainty is that the share of residential consumption constitutes around 40 percent of the total, while industrial consumption makes up only 20 percent of total metered sales.

Table 12 presents the results of the electricity intensity calculations. Generally, a low level of production capability leads to the growth of electricity intensity, other things being equal, due to a substantial proportion of non-production related electricity consumption (e.g., lighting, ventilation, etc.). The data contained in the table tend to confirm this.

The notion of electricity intensity may not be directly applied to budget organizations, since it is not clear which portion of GDP is represented by this subsector. It is composed of enterprises involved in real production along with organizations rendering services. The share of GDP consumed by organizations was considered to form this subsector. All further calculations were done on the basis of this presumption. GDP attributable to public utility services was assumed to be related to the electricity intensity involving the potable water supply. To arrive at the intensity of the subsector labeled “Other Services”, GDP for transport and communications was subtracted from the GDP related to the total services sector.

As mentioned earlier, a separate equation for public utility services was introduced into the production block of GDP to account for electricity consumption used to supply potable water. This category is present in official electricity consumption statistics and therefore was introduced into the model.

Table 12 -- Changes in electricity intensities of different sectors (1996 Dram)

		1997	1998	1999
Electricity intensity				
GDP	Wh/Dram	5.2418	5.0067	4.8612
Industry	Wh/Dram	4.6013	4.6013	4.4632
Budget Organizations	Wh/Dram	4.572	3.0773	3.0157
Irrigation	Wh/Dram	1.1097	1.8432	1.8536
Drinking Water	Wh/Dram	22.246	10.9588	8.9041
Transportation	Wh/Dram	3.4386	3.2658	3.2658
Other services	Wh/Dram	2.4018	1.1403	1.1514

Source: calculated on the basis of tables 10 and 11.

It is clear that the difference between intensities of 1997 and 1999 years may be caused only by two factors: changes in production capability use, or statistical discrepancies and inconsistencies of data. Results for 1998 may be treated as less representative because they actually were derived from half a year of data. The difference in intensities between 1997 and 1999 is especially noticeable for the production sectors. The most impressive reduction of electricity intensity is observed for the supply of potable water; this is understandable, since the output of this sector doubled between 1997 and 1998. Overall, a slight reduction in electric intensity occurred for the total GDP.

Industry should not be considered as representative sector, because it was not actually modeled; rather, assumptions about its development were directly introduced into the model.

4.5.3 ARMRESID: simulation of electricity consumption in residential sector

ARMRESID is used for projecting electricity consumption in the residential sector. Several major factors drive energy demand in this sector, the most important of which are population and its distribution by age, living area, the number of inhabitants per household, the saturation of major utility services and appliances, personal income, electricity tariffs, and urban and rural mix of population.

ARMRESID was developed to focus on the following factors:

- changes in population;
- the impacts of income growth;
- the restoration of natural gas supply for residential sector.

Among the parameters mentioned above, the first one is the most important in the determinant of energy consumption. Though the same rate of change in total population was assumed for different scenarios, this parameter is an exogenous variable and could be changed to reflect various views.

Personal income levels are well in agreement with general economic information. The data on final consumption of GDP in households, coupled with the dynamics of average monthly wages and electricity consumption per capita, provided the information needed to develop a correlation between future changes in well-being and electricity usage.

The third and last parameter represents a specific feature of the current situation in Armenia, because it not only strongly affects the amount of consumed electricity, but determines the daily pattern of consumption. Unfortunately, the impacts of the restoration of natural gas supply are not easy to simulate. This requires the analysis of electricity consumption for space and water heating, cooking, lighting, and domestic appliances.

A typical practice for many electric utilities would be to conduct load research on such end uses. A representative customer sample can be metered, and the results statistically extrapolated to the whole residential sector. At the same time, the larger the selection of customers considered, the less variation in their combined load can be observed. Therefore, the extrapolation of load characteristics of any limited group for the whole sector always requires smoothing procedures.

The simulation was performed in two steps. First, the results of load research conducted by Research Management Associates [3] in 1998 were used to construct the total combined load for the residential sector. Several different scenarios of natural gas supply restoration were created, using the RMA load data to determine the changes in the total system load shape. Then, these changes were incorporated into the real system load curves described in Table 5.

It should be noted that the data from [3] may not be representative results for Armenia. The principal reason for this is that the load curves were not derived by separate metering of hourly loads of various end uses; rather, the survey was conducted through a residential consumers questionnaire.

To take this factor into account, a special approach was taken. First, a typical load shape was derived by taking typical seasonal loads for single family homes and for 4-6 story apartment dwellings from [3] , and calculating a weighted average hourly consumption to represent combined loads for the sector as a whole. The relative proportions of single family homes and apartment dwellings were assessed on the basis of numbers of these two customer types from distribution companies (400,305 for single family houses and 285,695 for apartment dwellings). The resulting combined loads are presented in Figure 3.

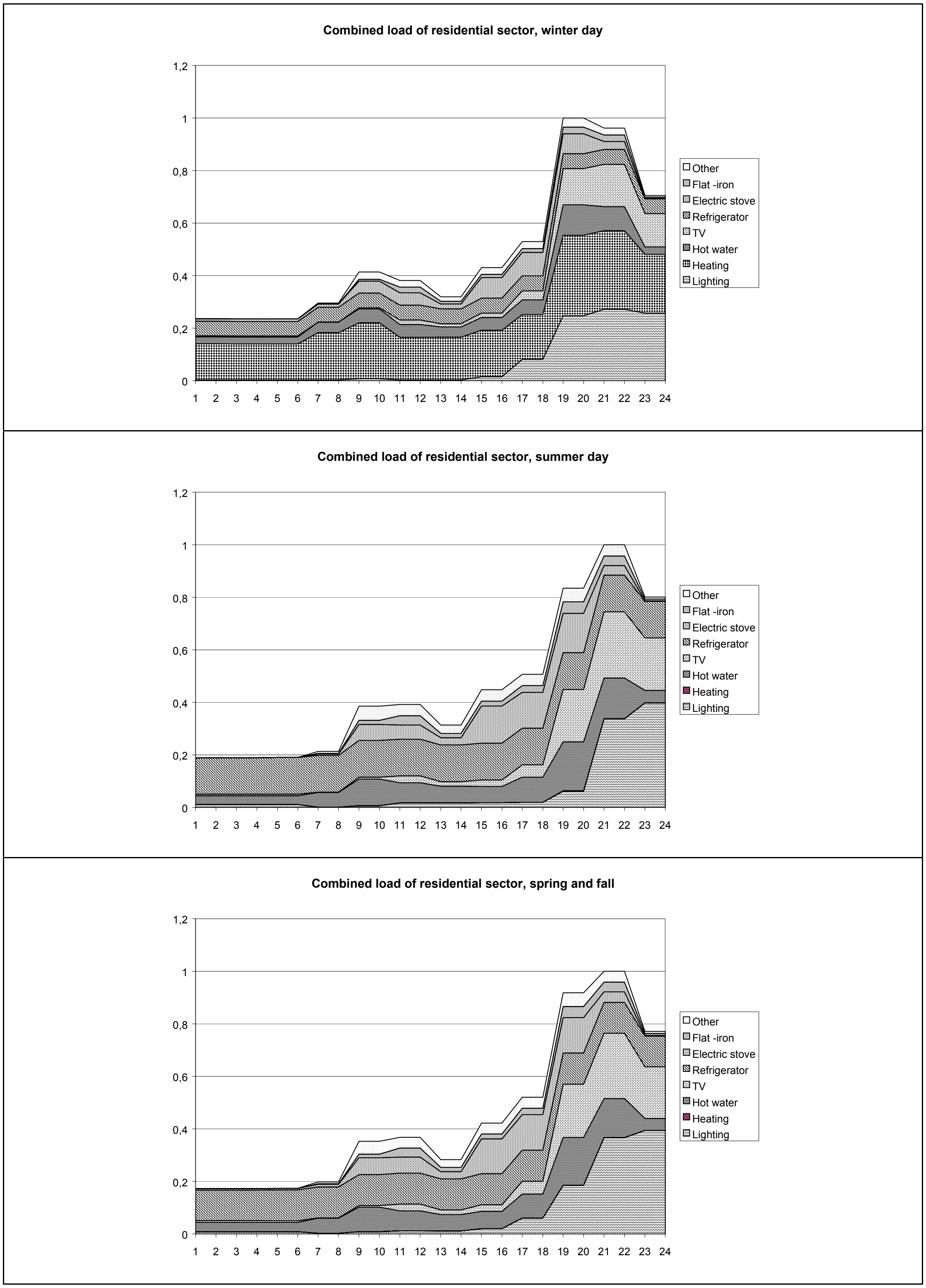


Figure 3 -- Synthesized seasonal load curves for residential sector

It was determined from [3] that 96 percent of the difference between daily summer consumption and daily winter consumption is due to space heating. This share was used to assess the total annual amounts of electric power used for space heating. The synthesized load shapes were then used to simulate changes caused by the restoration of the natural gas supply. First, by reducing electricity usage for space heating and water heating, and then by reducing the amount of electricity used for cooking. However, since cooking represents a relatively small share of consumption, the changes in the consumption pattern for this end use were deemed immaterial and thus were ignored for this analysis. This approach permitted the team to develop changes in load shapes for the residential sector, and to relate these changes to the rate of restoration of the natural gas supply.

According to the RMA study [3], electricity is used for space heating 24 hours a day; hourly levels will change only slightly. The assumption was therefore made that the restoration of the natural gas supply will reduce total consumption of electricity but will not change hourly load shape. This effect can be measured by changes in load factors for winter months' loads. The approach is illustrated by data from Table 13.

Table 13 -- Combined load of residential sector normalized for peak consumption (winter day)

Hour ending	1	2	3	4	5	6	7	8	9	10
Lighting	0,0028	0,0028	0,0028	0,0028	0,0028	0,0028	0,0032	0,0032	0,0076	0,0076
Heating	0,1379	0,1379	0,1372	0,1372	0,1372	0,1372	0,1798	0,1798	0,2126	0,2126
Hot water	0,0261	0,0261	0,0261	0,0261	0,0261	0,0261	0,0402	0,0402	0,0534	0,0534
TV	0,0040	0,0040	0,0040	0,0040	0,0040	0,0040	0,0000	0,0000	0,0042	0,0042
Refrigerator	0,0553	0,0553	0,0553	0,0553	0,0553	0,0553	0,0561	0,0561	0,0561	0,0561
Electric stove	0,0095	0,0095	0,0095	0,0095	0,0095	0,0095	0,0119	0,0119	0,0454	0,0454
Flat -iron	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0010	0,0010	0,0070	0,0070
Other	0,0006	0,0006	0,0006	0,0006	0,0006	0,0006	0,0033	0,0033	0,0277	0,0277
Total	0,2363	0,2363	0,2356	0,2356	0,2356	0,2356	0,2954	0,2954	0,4138	0,4138
Hour ending	11	12	13	14	15	16	17	18	19	20
Lighting	0,0030	0,0030	0,0028	0,0028	0,0149	0,0149	0,0812	0,0812	0,2467	0,2467
Heating	0,1622	0,1622	0,1628	0,1628	0,1772	0,1772	0,1711	0,1711	0,3071	0,3071
Hot water	0,0487	0,0487	0,0387	0,0387	0,0482	0,0482	0,0556	0,0556	0,1158	0,1158
TV	0,0168	0,0168	0,0123	0,0123	0,0169	0,0169	0,0341	0,0341	0,1380	0,1380
Refrigerator	0,0568	0,0568	0,0570	0,0570	0,0570	0,0570	0,0570	0,0570	0,0568	0,0568
Electric stove	0,0473	0,0473	0,0188	0,0188	0,0783	0,0783	0,0890	0,0890	0,0755	0,0755
Flat -iron	0,0216	0,0216	0,0099	0,0099	0,0121	0,0121	0,0147	0,0147	0,0253	0,0253
Other	0,0251	0,0251	0,0170	0,0170	0,0257	0,0257	0,0271	0,0271	0,0347	0,0347
Total	0,3813	0,3813	0,3192	0,3192	0,4304	0,4304	0,5299	0,5299	1,0000	1,0000
Hour ending	21	22	23	24	Total					
Lighting	0,2720	0,2720	0,2572	0,2572	1,7937					
Heating	0,2990	0,2990	0,2241	0,2241	4,6162					
Hot water	0,0918	0,0918	0,0278	0,0278	1,1970					
TV	0,1611	0,1611	0,1269	0,1269	1,0447					
Refrigerator	0,0561	0,0561	0,0561	0,0561	1,3494					
Electric stove	0,0306	0,0306	0,0019	0,0019	0,8548					
Flat -iron	0,0249	0,0249	0,0051	0,0051	0,2435					
Other	0,0260	0,0260	0,0056	0,0056	0,3877					
Total	0,9615	0,9615	0,7047	0,7047	11,4869					

Since space heating and hot water together account for demand on a normalized basis of 5.82, while the remaining processes consumed a total of 5.67, the total demand with the effects of restored natural gas supplies can be stated as follows:

$$\text{Energy consumption} = 5.67 + ((1-x) * 5.82),$$

where x = the percentage of reduction of space heating and hot water heating

Likewise, the reduced peak demand in this case equals 0.58+(1-x)*0.42. Here, 0.58 is the total load at the peak hour for all processes except space heating and hot water, which account for a total of 0.42.

These transformations permit the team to calculate the load shape for specific levels of restored gas supplies, which in turn are assigned specific impacts on water heating and space heating.

4.5.4 LOADSHAPE: calculation of system peak

The LOADSHAPE module was developed to calculate maximum system loads. It is also used to derive typical load curves for each month of the forecast period. The process of projecting load shapes consists of two steps. First, the load curve was derived for a system as a whole. It was necessary to consider in detail the development of consumption characteristics of each sector of the economy in this process. This approach required separate load shapes for each subsector, which were not available. Instead, proxies presented in Table 14 were used. These proxies represent the shapes of relative loads that have been normalized by individual maximum peaks. They demonstrate the shape of each load, but do not depend on the amount of consumed electricity.

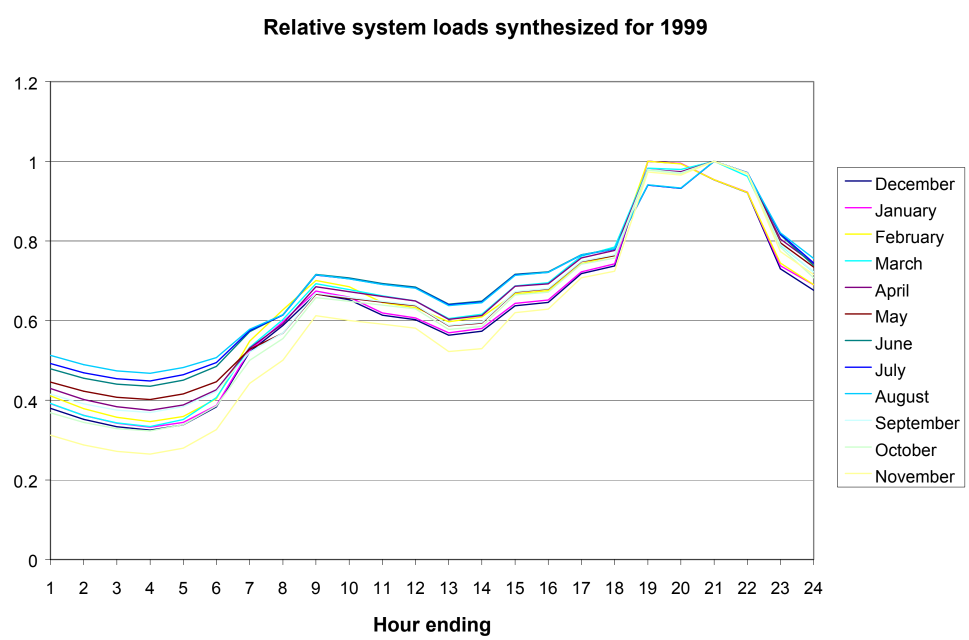


Fig. 3. Synthesized system loads for 1999

The combined system load was constructed from these sector loads in the same general way the residential sector was synthesized. This approach takes into account the different rates of development of each sector and thus incorporates changes in their relative contributions to the total picture. Relative system loads, which were constructed for 1999, using the data in Table 15, are presented in Figure 3.

These load shapes were used to evaluate changes in strategies for future economic development. These impacts were measured by load factor for the total system loads in 1999 and 2015. The resulting load factors of each monthly curve were calculated and compared. Since for both years the synthesized loads were used, a systematic error was eliminated as a result of such a comparison. Changes in load factors for three economic growth scenarios are presented in Table 14.

Table 14 -- Changes in densities of total system load for different scenarios

	Low case		Medium case		High Case	
	Restoration of natural gas supply	Without restoration	Restoration of natural gas supply	Without restoration	Restoration of natural gas supply	Without restoration
December	0.033053	0.007667	0.028327	0.003557	0.043201	0.003339
January	0.033053	0.00721	0.028095	0.002907	0.042304	0.001934
February	0.032432	0.008213	0.027253	0.003724	0.04095	0.00324
March	0.001203	0.001203	-0.00344	-0.00344	-0.00558	-0.00558
April	0.005547	0.005547	0.0012	0.0012	-0.00067	-0.00067
May	0.009017	0.009017	0.006189	0.006189	0.005229	0.005229
June	0.010721	0.010721	0.007841	0.007841	0.007938	0.007938
July	0.011333	0.011333	0.008829	0.008829	0.008795	0.008795
August	0.011534	0.011534	0.009607	0.009607	0.00796	0.00796
September	0.006163	0.006163	0.002723	0.002723	0.000557	0.000557
October	0.004358	0.004358	-0.00035	-0.00035	-0.00143	-0.00143
November	0.001559	0.001559	-0.00401	-0.00401	-0.00713	-0.00713

It is noteworthy that only winter month load factors substantially vary for these different cases, ranging between 2 and 4 percent for these months. For the rest of the year, changes in load factor average less than 1 percent, except for the low case scenario.

Table 15 -- Relative load shapes

Hour ending	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
Industry*	0.38	0.34	0.32	0.33	0.35	0.50	0.81	0.94	0.99	1.00	0.99	0.98	0.98	0.99	0.99	0.97	0.97	0.98	0.98	0.94	0.95	0.94	0.76	0.44	18.81
Machine building*	0.50	0.46	0.43	0.43	0.45	0.46	0.48	0.80	0.92	1.00	0.96	0.91	0.93	0.95	0.98	0.97	0.93	0.89	0.88	0.84	0.78	0.70	0.61	0.44	17.70
Transportation*	0.46	0.40	0.38	0.37	0.45	0.63	0.79	0.86	0.83	0.77	0.70	0.66	0.69	0.71	0.71	0.74	0.81	0.90	0.93	1.00	0.91	0.74	0.61	0.57	16.62
Technological load of utility services sector*	0.44	0.35	0.26	0.21	0.23	0.31	0.67	0.94	1.00	0.94	0.86	0.83	0.77	0.80	0.81	0.88	0.94	0.99	0.93	0.86	0.79	0.69	0.61	0.57	16.69
Lighting*	0.13	0.11	0.09	0.10	0.13	0.20	0.67	0.89	0.88	0.73	0.60	0.55	0.48	0.51	0.50	0.58	0.79	0.98	1.00	0.95	0.87	0.57	0.27	0.20	12.75
Construction**	0.50	0.46	0.43	0.43	0.45	0.46	0.48	0.80	0.92	1.00	0.96	0.91	0.93	0.95	0.98	0.97	0.93	0.89	0.88	0.84	0.78	0.70	0.61	0.44	17.70
Agriculture***	0.38	0.34	0.32	0.33	0.35	0.50	0.81	0.94	0.99	1.00	0.99	0.98	0.98	0.99	0.99	0.97	0.97	0.98	0.98	0.94	0.95	0.94	0.76	0.44	18.81
Commercial**	0.46	0.40	0.38	0.37	0.45	0.63	0.79	0.86	0.83	0.77	0.70	0.66	0.69	0.71	0.71	0.74	0.81	0.90	0.93	1.00	0.91	0.74	0.61	0.57	16.62
Budget organizations**	0.44	0.35	0.26	0.21	0.23	0.31	0.67	0.94	1.00	0.94	0.86	0.83	0.77	0.80	0.81	0.88	0.94	0.99	0.93	0.86	0.79	0.69	0.61	0.57	16.69
Irrigation**	1.00	1.00	1.00	1.00	1.00	0.90	0.70	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	16.80
Potable water**	0.44	0.35	0.26	0.21	0.23	0.31	0.67	0.94	1.00	0.94	0.86	0.83	0.77	0.80	0.81	0.88	0.94	0.99	0.93	0.86	0.79	0.69	0.61	0.57	16.69
Other**	0.46	0.40	0.38	0.37	0.45	0.63	0.79	0.86	0.83	0.77	0.70	0.66	0.69	0.71	0.71	0.74	0.81	0.90	0.93	1.00	0.91	0.74	0.61	0.57	16.62
Export****	0.87	0.81	0.78	0.75	0.74	0.75	0.84	0.98	0.98	0.96	0.93	0.91	0.93	0.97	0.96	0.95	0.94	0.98	0.99	1.00	1.00	1.00	1.00	0.97	21.97

Source: *) Typical daily load curves for sectors marked * were taken from [1].

**) Budget organizations and potable water supply were assume to have the same load shape as technological load of utility services sector, for construction a load shape of machine building sector was taken, load shape for irrigation was derived after consultations with local experts;

***)Agriculture was assumed to have the same load shape as industry since for the latter a shape of light industry was taken from [1];

****) Actual hourly load profile of export supply to Georgia for January 1999 was used for export.

In general, the system load factor is affected by the relative rates of development of different sectors of economy, plus the amount of heating load substituted by natural gas. Since the rates of development for each considered sector in this analysis were of an equal order of magnitude, this factor did not produce large changes. The changes in load factors can instead be traced to the different scenarios for winter months, an effect that is due solely to the substitution of gas for electricity.

Based upon the assumption that the same amount of load is substituted by gas during all hours in each day, it is possible to represent changes of relative loads in analytical form. The following calculations were used to determine the monthly values of system peak demand and the shape of the total system load.

Let S^0, D^0 and X^0_i denote total daily energy consumption (the area under the hourly load curve), load factor, and the hourly value of a relative load. Let Δ denotes a constant load decrement that would cause the new relative load to have a load factor equal to D^1.

For any relative load curve, total energy equals the load factor times 24. Once each hourly load has been reduced by Δ, a new peak load becomes 1-Δ. Therefore, having been normalized by the value of new peak each hourly load becomes equal to:

$X_i^1 = \frac{X_i^0 - \Delta}{1 - \Delta}$. From the equation for total daily energy, $\sum_{i=1}^{24} \frac{X_i^0 - \Delta}{1 - \Delta} = 24 * D^1$.

A formula for Δ can then be derived: $\Delta = \frac{D^0 - D^1}{1 - D^1}$.

For the peak hour $X_i^0 = 1$; therefore, the denominator and numerator cancel and $X^1_I=1$. This means that the properties of relative load do not change for the peak hour. However, as we move to values farther away from the peak, the relative change in energy increases. In summary, the peak remains unchanged, while the total energy under the curve is reduced; this results in a deteriorating load factor over time.

Such a transformation was applied to derive a revised load shape with new load factors. The difference between the initial load shape and the curve in 2015 is illustrated in Figure 4.

The calculation of monthly electricity consumption was done on a basis of projections for annual energy consumption, the distribution of consumption by months, the number of days in every months and relative load shape. To calculate the monthly distribution of energy consumption, statistics for November, 1998, through December, 1999, from the Yerevan and the Central distribution companies were used.

Exports of electricity to Georgia take place during December-April, with the major portion being shipped in winter. The level of export is less in December in comparison to January and February, since actual deliveries during this month has to bring into balance the total amount of exported electricity for the year.

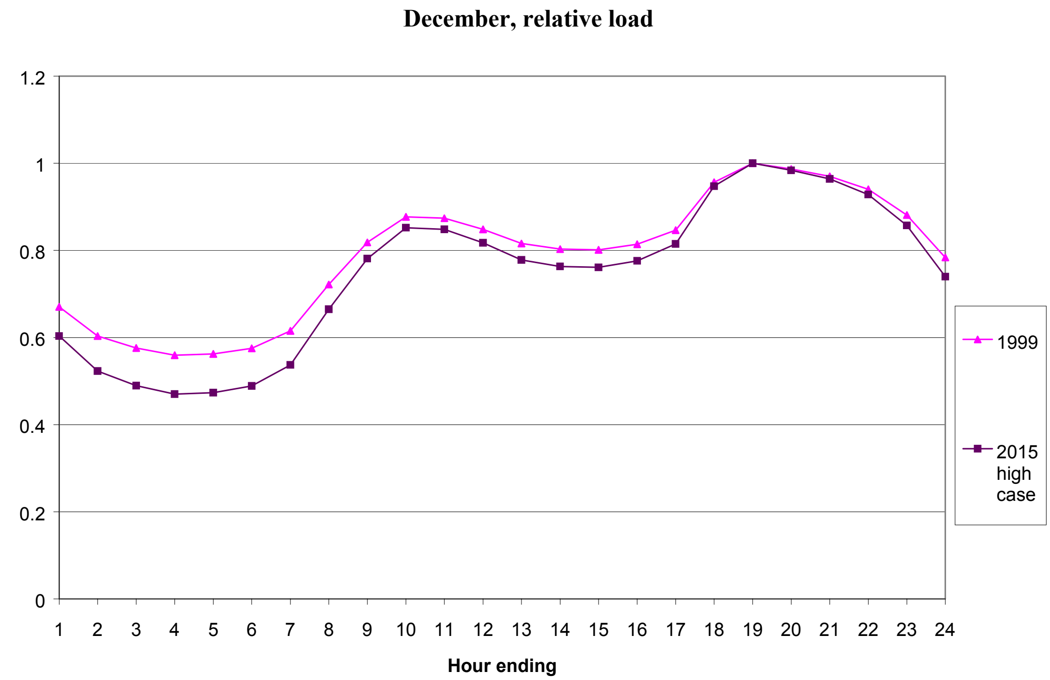


Figure 4. Load shape for December 2015, high case

Table 16 presents profiles of monthly consumption for each of the customer categories that are used in the model. To check for consistency with real data, total generated energy derived from dispatch data for 1998 and 1999 is also provided in the Table.

Table 16 -- Distribution of annual consumption by months for different sectors

Month of year	# of days	Resid. sector	Industry	Budget org.	Irrigation	Trans port	Other	Potable water	Export to Georgia	Total calculated for 1999	Actual generation data for 1999
December	31	11.7%	8.5%	14.9%	3.3%	10.8%	11.7%	8.6%	16%	10.2%	10.3%
January	31	11.4%	7.1%	15.9%	2.3%	9.6%	11.4%	8.8%	25%	10.3%	10.6%
February	28	9.1%	7.2%	14.5%	2.4%	8.1%	9.1%	8.3%	25%	9.1%	8.9%
March	31	8.9%	10.3%	10.5%	5.1%	19.2%	8.9%	8.6%	17%	9.8%	9.1%
April	30	7.6%	7.7%	7.5%	7.9%	7.3%	7.6%	7.8%	17%	8.2%	7.6%
May	31	7.0%	7.1%	5.4%	12.4%	6.3%	7.0%	7.5%	0%	7.1%	7.6%
June	30	6.6%	9.6%	4.2%	14.1%	6.2%	6.6%	7.9%	0%	7.6%	7.6%
July	31	6.9%	9.2%	4.3%	15.6%	6.6%	6.9%	8.1%	0%	7.9%	7.8%
August	31	6.9%	7.9%	4.1%	17.3%	6.3%	6.9%	9.6%	0%	7.9%	7.8%
September	30	6.9%	8.1%	4.2%	9.8%	5.9%	6.9%	8.7%	0%	7.0%	6.8%
October	31	7.6%	9.7%	5.4%	6.7%	6.2%	7.6%	7.8%	0%	7.2%	7.0%
November	30	9.5%	7.7%	9.2%	3.1%	7.4%	9.5%	8.3%	0%	7.6%	8.9%

The forecasting methodology described thus far permits to us calculate regular monthly peaks, but does not take into account stochastic deviations caused mainly by weather conditions. For a number of years, the absolute system peak has occurred at 19:00 and has substantially exceeded the average value of regular maximum loads for non-peak days. The ambient temperature makes a substantial contribution to the load variations. To account for these effects, monthly deviations from average peaks were calculated and applied to the projections.

Table 17 shows the deviations of actual maximum loads from average statistical maximum loads (regular peaks) as a percent of the latter. For all months except December the spikes were caused by abnormal weather conditions, which can be considered a stochastic variable. In December, such a deviation is a regular phenomenon (it has been observed at 19:00 on December 31 for two subsequent years). Therefore, the difference between regular peaks and actual maximum load for this month may not be treated as a stochastic variable. For this reason the latest observed value is used for further calculations.

Table 17 -- Deviations of actual monthly maximum loads from regular maximum load

	Jan. (%)	Feb. (%)	Mar.(%)	Apr. (%)	May. (%)	Jun. (%)	Jul. (%)	Aug. (%)	Sep. (%)	Oct. (%)	Nov. (%)	Dec. (%)
1998	7.1	12.4	13.7	20.3	15.6	8.4	5.3	6.5	11.1	14.8	5.3	21.6
1999	7.1	6.1	7.5	10.2	9.9	5.7	8.1	10.9	12.5	15.6	9.9	13.4
2000	9.9	7.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
max	9.9	12.4	13.7	20.3	15.6	8.4	8.1	10.9	12.5	15.6	9.9	13.4

Source: compiled by the authors on the basis of actual dispatch data for 1998-2000.

Having calculated the value of end-use consumption, one needs to account for all types of losses in order to arrive at generation requirements. Two approaches exist to calculate this value.

The first is based on total sales, differentiated by voltage levels. This approach would take into account technical and commercial losses for each voltage class. Then, these values can be converted into total losses. Unfortunately, this method requires projections of sales by voltage, which do not exist for Armenia.

The second approach is not as detailed, but it allows the planner to get from total metered sales to the energy delivered by generators to the high voltage (HV) grid. In 1998, the total amount of electricity delivered to the HV grid equaled 5,684 GWh at the same time metered sales amounted to 3,594 GWh, and net exports reached 207 GWh. The combined amount of losses excluding auxiliary consumption of generators therefore reached 33.1 percent[1]. In 1999, these indicators were equal to 5,316 GWh, 3,621 GWh, and 241 GWh, respectively, resulting in a 27.3 percent loss for the system.

The high level of total system losses is caused by large amounts of electricity either not billed for or stolen from the system. The 6 percent reduction in system losses over the one-year period was achieved by a substantial reduction of commercial losses in the distribution system. Table 18 presents the estimates of these losses.

[1] $(5{,}684 - 3{,}594 - 207) / 5{,}684 \approx 0.331$

Table 18 -- Estimates of losses

		1998	1999
Gross generation[a]	GWh	6140	5716
Self-consumption of generators[a]	%	7.4%	7.0%
Delivery to HV grid[a]	GWh	5686	5316
Total losses in HV grid[a]	%	7.7%	6.7%
Total for Resale[a]	GWh	5248	4960
Net export[a]	GWh	207	241
Actual purchase by Discos[a]	GWh	5041	4719
Should have been purchased to provide for metered sales[b]	GWh	4084	4115
Electricity purchased to provide for unmetered supply[b]	GWh	957	604
Technical losses in distribution network[c]	%	12.0%	12.0%
Metered sales[a]	GWh	3594	3621
Unmetered supply[b]	GWh	842	531
Commercial losses as % of metered sales[b]	%	23.4%	14.7%

Source: USAID – Government of Armenia Memorandum of Understanding, Annex 3 Energy and Financial Report, Reporting Periods: 1/1/1998-12/31/1998, 1/1/1999-01/01/2000.
Calculated from metered sales assuming technical losses 12%.
Total losses for distribution companies after privatization that have been allowed by ERC.

Commercial losses consist of two parts, the first being electricity not billed, and the second electricity stolen or not metered properly because of the poor technical operation of meters. According to different experts, out of 15 percent total losses the latter constitutes about 3 percent. This assumption is reasonable, given the existence of Gosenergonadzor in Armenia, which is responsible for the supervision of energy consumption.

For forecasting purposes, it is assumed that following the privatization of the distribution companies, the payable demand for electricity will increase by an amount equal to the power that currently is not paid for. It is assumed that such a transformation will be finished by 2005. This means that total combined end-use demand, paid and not paid at present, will be reduced by 3% after year 2005. It is also assumed that self-consumption of generators will remain at the same level during the forecasting period. The losses for the high voltage system will gradually diminish to 6 percent, and technical losses in the distribution network will be reduced from 12 percent to 9 percent in five years.

4.6 Electricity Demand in Armenia: 2000-2015

The average annual rate of GDP growth amounted to 5.8 percent in 1994-1998, with a slow-down observed in 1999; growth in that year constituted only 5.2 percent. Prospects for sustainable strong growth are unclear, since there are a number of obstacles for accelerated economic development, which raises questions about sustainable growth of energy demand.

Some of the major obstacles to economic and energy demand growth are Armenia's strong dependence on foreign resources to finance investments, its relatively large external debt, and the lack of primary domestic fuel resources. Even though imports exceeded exports by a smaller amount in 1998 than in previous years, in order to sustain significant economic growth, the continuation of official support from foreign governments and international financial institutions must continue at least at the current levels. High growth rates in electricity demand can only be expected to occur in the case of a much higher inflow of private investment into Armenia.

Presently the country imports 100 percent of its natural gas, oil and oil products. Hard coal is also completely shipped from abroad.

In 1998, Armenia exported goods and services to Russia for US $39 million, while imports amounted to US $191 million. Gas-fired electric power plants consume approximately 800 million cubic meters (c.m.) a year, which constitutes half of total domestic consumption of natural gas. Gas consumed for electricity production costs about US $42.4 million, or 22 percent of the total imports from Russia. As domestic economic activity declines and energy import prices rise rapidly, Armenia's ability to import energy becomes progressively limited.

Therefore, different scenarios of future economic growth are to be developed. For the purposes of this study three scenarios of GDP growth were selected.

A number of assumptions are common for all these scenarios. At present, the population is 3.193 million people, and it will diminish at a rate of 0.2 percent a year; by 2015 it therefore will be approximately 3.087 million people. Calculations are also based on a tendency to reduce consumption of electricity for irrigation. Impacts of price changes for electricity were not considered.

Slow growth scenario (Table 19). This scenario was based on the assumption that the economy as a whole will grow at 3 percent a year. This assumption corresponds to the lowest rates of economic development observed during the past five years.

A number of reasons argue that this growth is a reasonable estimate. First, the rate of capital accumulation would remain at the same level that was achieved through the considered time interval, meaning that investment remains at the modest 17 percent of GDP, and will provide for growth in the different sectors at the level of 1.8 to 3.3 percent (in real terms). Industry is assumed to grow at 3 percent a year, while its energy intensity will gradually decline mainly due to increased use of production capacities.

The flow of debt is assumed to gradually decline from the present level, and in five years the country will begin to pay back its borrowings. The flow of additional resources will diminish 10 percent a year from current levels, and after 2007 it will remain steady at approximately 50 percent of the current level.

These parameters actually assume that external debt will continue to grow, and that it will reach about 50 percent of GDP in 2005; however, after that it will be slowly reduced to 30 percent of GDP in 2015.

It is important to note that it is assumed that additional resources are not actually used for investment, which implies that primary sources of investments are domestic production plus external assistance. In other words, additional resources support the import of the goods and services consumed in households and, therefore, mainly determine the level of current consumption.

Governmental policy supports the absolute level of investments at least at the current level and increases them by 63 percent by 2015 in real terms. That would provide for modest growth of the major sectors of the economy. However, as mentioned above, industrial growth supported by direct private investments is assumed throughout the whole forecasting process.

This scenario assumes industrial growth of 3 percent a year, accompanied by 2 percent growth of electricity consumption. Such a growth rate can be sustained without attracting large amounts of resources from abroad. Therefore, those rates can be sustained for a long period of time. At the same time, irrigation will reduce its electricity usage by 0.5 percent a year.

This scenario also takes into account a maximum income elasticity of residential consumers of 0.2. It was also assumed that complete restoration of the natural gas supply will take 15 years, beginning in 2005. For the forecast period, two thirds of space heating and water heating load will be transferred to natural gas.

This scenario translates into an average 1.6 percent growth rate of final electricity consumption. The highest growth -- 3.9 percent -- will be observed in the utility sector, followed by transportation with 3.3 percent a year. It is assumed that diminishing electricity intensity in industry would lead to 2 percent growth of industrial consumption.

In terms of maximum load, absolute system peak demand will rise from 1,070 MW in 1999 to 1,295 MW in 2015. Generators will increase their net production from a current 5,279 GWh to 6,819 GWh by the end of the forecast period.

Medium growth scenario (Table 20). This scenario is based on the presumption that the country will manage to use domestic resources better to achieve higher rates of economic growth. As in the case of the low growth scenario, the same flows of external debt and additional resources are assumed. The annual growth rate of investments from domestic sources will be on average 1 percent higher than for the previous case.

Industry is the main source of growth for the medium and high scenarios; it is assumed that it will grow 6 percent a year. At present, it is difficult to estimate the level of direct investments required to sustain such a growth rate for 15 years, given that for the most recent five years industrial performance was less than moderate.

It is assumed that a combination of industrial growth coupled with improved policies on the allocation of domestic resources to increase investments will permit the country to sustain a 4 percent growth rate. Construction and total services will perform better, while agriculture remains practically at the same level. Trade and public utility services will increase their production by 0.6 and 1.5 percent, respectively.

Higher industrial growth will be accompanied by relatively smaller growth of electricity consumption. Electricity intensity in this sector will be reduced more than for the slow growth scenario, not only because of enhanced use of production capability; future industrial development will also be achieved through the application of new energy efficient production technologies. Therefore, for the medium growth scenario, a 2.8 percent growth rate in industrial electricity consumption was assumed.

This scenario is also characterized by relatively higher consumption in budget organizations, due to a reduction in the practice of rationing electricity consumption. This is in turn due to the fact that more resources will be available in the budget to pay for electricity.

Higher growth rates of electric power consumption will be observed in utility services and transportation sectors. The former will be caused by improved water supply services, while the latter will be due to higher industrial activity.

The reduction of electricity consumption in irrigation will take place at double the pace in the previous scenario, and will actually correspond to a targeted rate of 1 percent a year.

Assumptions for the residential sector were retained from the previous case.

All in all, the medium case scenario is characterized by a 2.2 percent growth of final consumption of electricity, which requires an increase in net annual generation to 7,475 GWh (versus 6,816 GWh in low case). This will cause December's peak consumption to reach 1,438 MW, against 1,295 MW for the low case.

High growth case (Table 21). This scenario is based on slightly higher expectations of direct investments into industry. It assumes industrial growth rates to be sustained at a level of 6.2 percent annually, which in turn will cause electricity consumption to grow by 3 percent a year.

Further improvement in usage of domestic resources is assumed for this scenario. The investment share of GDP will grow faster than for the previous cases. It is assumed that by 2005, the share of investments will reach 18 percent GDP; by 2012 it will reach 20 percent, and 22 percent in 2015 (as compared to 17.2percent at present).

Performance of various sectors will be substantially better. Restoration of utility services will take place much faster. The same is true for development of trade and construction, all of which will drive electricity consumption up.

The increases are attributed primarily to budget organizations and the residential sector. Due to increased availability of resources, the restoration of the natural gas supply will take only eight years (instead of fifteen, as in previous two cases). This will start in 2005 and will be completed by 2012, and will reduce electricity consumption in the residential sector. On the other hand, income elasticity is assumed to be 0.3 (50 percent higher than the value in the previous cases) which will more than make up for the mentioned reduction in consumption. All in all, consumption in the residential sector will grow at 2.8 percent a year, or 0.7 percent higher than in the medium case.

Total consumption of electricity for the high case will grow at 3.2 percent a year on average. Net annual generation increases to 8,604 GWh, and maximum demand reaches 1,655 MW in December 2015.

4.7 Cross-Check with Other Official Sources

In December, 1999, the Energy Regulatory Commission (ERC) of the Republic of Armenia released its study entitled Quantitative Assessment of Trends in the Armenia Energy Sector up to Year 2010. An analysis of possible variants of Armenia power sector development is presented in the report, a substantial part of which was devoted to the forecasts of future demand in electric and thermal power, as well as natural gas. This study presents the most updated view of an official organization on the matters related to future consumption of electric energy. Table 22 presents the results of the study.

Two different scenarios of economic development are considered in that study, which are associated with different projections of electric power generation. Unfortunately, direct comparison with the ERC results can not be done. At the time when the study was being performed, the data for the whole year of 1999 was not yet available; therefore the authors, first, projected total indicators for 1999, and then used it as a starting point for their long term forecast.

To prepare a basis for comparison, growth rates were first calculated for the most important indicators: gross production of electricity and the load factor of the system. The value given for gross production represents the position of the ERC on the scale of final sales of electricity, changes in net exports, and progress on the reduction of technical and commercial losses. In other words, this parameter provides a good indication of the Commission's opinion with respect to further development of the energy system. The load factor permits us to determine the maximum load of the system, given the corresponding level of gross generation.

As a result of discussions with the ERC, it was agreed that during the first three years following the privatization of the distribution companies, no growth will occur in electric demand. These assumptions were applied to update the Commission's forecast and to compare it with the results of the current study. The updated version is presented in the second half of Table 22.

As the Table indicates, there is no significant discrepancy with respect to maximum system load until 2010, though the associated amounts of electric energy differ. According to the ERC, in 2010 peak demand will fall somewhere between 1,240 and 1,450 MW, and Hagler Bailly (HB) forecasts the same parameter between 1,230 and1,430 MW. In terms of energy, the discrepancy reaches a considerable value: 6,836-8,054 versus 6,323-7,142 GWh.

The main reason for such a deviation is that in the Commission's opinion, the annual system load factor will grow in the future due to the impacts of time-of-use tariffs and improved industrial development. The current HB forecast, on the other hand, does not envisage the appearance of three-shift production processes or an accelerated development of energy intensive enterprises.

Regardless of these differences, both forecasts present a good consensus on the primary indicator that will drive future capacity additions to the system.

References:

1. Economics of formation of electric energy systems/Volkenau I.M., Zeiliger A.N., Khabachev L.D.; Edited by Troitsky A.A., - Moscow, Energy, 1981.
2. 3-years Least Cost Development Programme for Electric Power Sector of Armenia, Yerevan 1999.
3. Demand-Side Management Program for the Republic of Armenia, Resource Management Associates of Madison, Inc., 1998.

Table 19 -- Slow growth scenario

GDP by Sector (at constant prices of 1996, bln Dram)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	*Growth rate*
Total produced GDP	**787**	**800**	**834**	**841**	**866**	**880**	**907**	**922**	**938**	**969**	**1015**	**1050**	**1100**	**1142**	**1188**	**1230**	**1260**	*3.0%*
Industry	168	171	178	183	189	195	200	207	213	219	226	233	240	247	255	262	270	*3.0%*
Construction	65	64	67	67	70	72	74	73	75	84	90	93	100	104	110	111	110	*3.3%*
Agriculture	246	244	253	252	259	260	265	267	267	270	282	288	299	307	315	325	330	*1.8%*
Total services	229	240	244	244	246	248	253	256	260	263	272	280	290	300	311	322	331	*2.3%*
Transport and communications	56	56	60	59	62	63	66	67	69	72	74	76	80	83	87	91	93	*3.3%*
Trade	79	82	83	78	80	80	83	84	86	89	95	99	106	111	118	124	130	*3.1%*
Public Utility Services	34	31	33	30	33	32	32	28	25	30	35	45	48	50	57	57	54	*3.0%*
Total value added	708	718	742	746	764	774	793	804	815	837	869	894	929	958	991	1020	1042	*2.4%*
Net Indirect Taxes	78	82	93	94	102	106	114	118	123	132	146	156	171	183	197	210	219	*6.6%*
Total sales of electric energy (GWh)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	***Growth rate***
Residential	1475	1505	1583	1621	1650	1675	1688	1699	1704	1707	1719	1733	1746	1762	1775	1788	1796	*1.2%*
Industry	748	755	778	794	810	826	842	859	876	894	912	930	949	968	987	1007	1027	*2.0%*
Budget Organizations	229	237	250	247	249	248	250	249	248	251	257	261	267	272	277	281	282	*1.3%*
Irrigation	456	454	451	449	447	445	442	440	438	436	434	432	429	427	425	423	421	*-0.5%*
Utility services	300	320	355	328	354	342	338	302	267	321	365	468	502	512	584	586	552	*3.9%*
Transportation	191	192	204	204	213	217	226	229	236	246	255	262	276	286	300	311	320	*3.3%*
Other customers	200	206	207	207	206	207	209	213	214	215	221	228	234	243	250	259	267	*1.8%*
Total Domestic consumption	***3599***	***3668***	***3829***	***3849***	***3928***	***3959***	***3996***	***3991***	***3983***	***4069***	***4162***	***4313***	***4404***	***4469***	***4598***	***4654***	***4664***	*1.6%*
Net export	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	
Total supply from the system	**3833**	**3902**	**4062**	**4083**	**4162**	**4193**	**4230**	**4225**	**4217**	**4303**	**4396**	**4546**	**4637**	**4703**	**4832**	**4888**	**4898**	
Net generation (GWh)	**5279**	**5417**	**5527**	**5483**	**5519**	**5489**	**5467**	**5461**	**5450**	**5562**	**5684**	**5880**	**5999**	**6085**	**6253**	**6326**	**6339**	
Gross generation (GWh)	**5676**	**5825**	**5943**	**5896**	**5934**	**5902**	**5878**	**5872**	**5860**	**5981**	**6112**	**6323**	**6451**	**6543**	**6723**	**6802**	**6816**	

Table 19 (continued from previous page) -- Slow growth scenario

Regular system peaks (MW)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Winter																	
December	944	972	993	987	994	990	991	995	998	1021	1046	1083	1110	1130	1164	1184	1192
January	922	949	970	964	971	966	967	970	972	994	1018	1054	1079	1099	1132	1149	1157
February	908	933	954	947	954	949	950	952	954	976	1001	1038	1062	1082	1115	1132	1139
Spring																	
March	916	939	960	953	961	957	957	957	958	979	1002	1035	1058	1075	1106	1122	1127
April	814	834	850	844	849	844	841	841	840	857	875	905	923	936	961	973	975
May	709	726	739	732	736	731	728	727	726	741	758	785	801	813	836	846	848
Summer																	
June	736	753	766	759	763	758	755	755	754	771	788	817	833	846	870	880	883
July	720	736	748	741	745	740	736	736	735	751	768	795	811	823	846	856	859
August	739	756	769	760	764	757	753	751	748	766	784	815	832	843	869	879	879
Fall																	
September	736	755	770	763	768	763	760	759	756	775	794	826	844	856	883	894	895
October	745	765	782	776	782	778	775	776	775	793	812	842	860	874	900	911	914
November	764	788	807	802	808	805	802	802	800	818	837	869	888	902	929	941	943
Actual system peaks (MW)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Winter																	
December	1070	1102	1126	1120	1127	1123	1124	1128	1132	1157	1186	1229	1258	1282	1320	1342	1352
January	1014	1043	1066	1059	1067	1062	1062	1066	1068	1092	1119	1159	1186	1208	1244	1263	1271
February	1021	1049	1072	1064	1072	1067	1067	1070	1072	1097	1125	1166	1194	1216	1253	1272	1280
Spring																	
March	1042	1068	1092	1084	1093	1089	1088	1089	1090	1114	1139	1177	1203	1223	1258	1275	1282
April	980	1004	1023	1015	1021	1016	1012	1012	1010	1031	1053	1089	1110	1126	1157	1170	1173
May	819	840	855	847	851	845	842	841	839	857	876	908	926	940	967	978	980
Summer																	
June	798	817	830	823	827	822	819	819	818	836	855	885	903	917	943	954	957
July	778	796	809	801	805	800	796	796	795	812	830	860	877	890	915	926	928
August	820	838	852	843	847	840	835	833	830	849	869	904	922	935	963	974	975
Fall																	
September	828	850	867	858	864	859	855	853	851	871	893	929	949	964	993	1006	1007
October	861	885	903	897	904	899	896	897	896	916	938	973	994	1010	1040	1053	1057
November	840	866	887	881	888	884	881	881	879	899	920	955	976	991	1020	1034	1037

Table 20 -- Medium growth scenario

GDP by Sector (constant prices of 1996, bln Dram)																		
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	***Growth rate***
Total produced GDP	**787**	**806**	**845**	**858**	**889**	**909**	**945**	**975**	**1010**	**1049**	**1100**	**1148**	**1206**	**1264**	**1326**	**1393**	**1464**	***4.0%***
Industry	168	175	188	199	211	224	237	252	267	283	300	317	336	357	378	400	424	***6.0%***
Construction	65	64	66	67	69	70	74	75	78	82	87	90	96	100	105	110	116	***3.7%***
Agriculture	246	244	253	252	259	260	265	267	267	270	282	288	299	307	315	325	330	***1.8%***
Total services	229	240	244	244	245	247	251	255	261	266	273	281	290	300	311	322	334	***2.4%***
Transport and communications	56	56	60	59	62	63	66	67	69	72	74	76	80	83	87	91	93	***3.3%***
Trade	79	83	84	80	82	82	86	88	91	96	102	107	114	120	127	134	141	***3.7%***
Public Utility Services	34	32	33	32	34	34	35	35	34	37	41	51	54	56	64	68	72	***4.8%***
Total value added	708	722	749	759	781	795	820	841	865	893	929	963	1004	1044	1088	1135	1185	***3.3%***
Net Indirect Taxes	78	84	96	100	109	115	125	134	144	156	171	185	203	220	238	258	279	***8.3%***
Total sales of electric energy (mln kWh)																		
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	***Growth rate***
Residential	1475	1518	1629	1685	1732	1770	1796	1821	1845	1867	1890	1916	1942	1971	1999	2028	2059	***2.1%***
Industry	748	758	790	813	835	859	883	907	933	959	986	1013	1042	1071	1101	1132	1163	***2.8%***
Budget Organizations	229	250	278	277	281	282	286	289	293	299	306	313	322	331	340	349	360	***2.9%***
Irrigation	456	451	447	442	438	434	429	425	421	417	412	408	404	400	396	392	388	***-1.0%***
Utility services	300	290	296	283	302	296	304	303	291	314	349	432	454	473	531	567	591	***4.3%***
Transportation	191	192	202	200	207	209	217	220	226	232	240	246	255	262	272	283	294	***2.7%***
Other customers	200	206	207	207	207	208	210	214	218	222	228	235	242	250	259	268	278	***2.1%***
Total Domestic consumption	***3599***	***3666***	***3850***	***3908***	***4003***	***4057***	***4125***	***4180***	***4227***	***4309***	***4412***	***4563***	***4660***	***4758***	***4899***	***5020***	***5133***	*2.2%*
Net export	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	
Total supply from the system	**3833**	**3900**	**4083**	**4141**	**4236**	**4291**	**4359**	**4413**	**4461**	**4543**	**4645**	**4797**	**4894**	**4992**	**5133**	**5253**	**5367**	
Net generation (GWh)	**5279**	**5432**	**5556**	**5563**	**5619**	**5619**	**5636**	**5707**	**5768**	**5876**	**6009**	**6207**	**6334**	**6462**	**6646**	**6803**	**6951**	
Gross generation (GWh)	**5676**	**5840**	**5974**	**5982**	**6042**	**6042**	**6060**	**6136**	**6203**	**6318**	**6462**	**6674**	**6811**	**6948**	**7146**	**7315**	**7475**	

Table 20 (continued from previous page) -- Medium growth scenario

Regular system peaks (MW)		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Winter																		
	December	944	978	1006	1009	1021	1022	1030	1047	1064	1087	1115	1154	1182	1211	1248	1283	1316
	January	922	955	982	985	996	998	1005	1021	1036	1058	1085	1122	1148	1175	1211	1244	1275
	February	908	939	965	967	977	978	985	1001	1015	1037	1064	1101	1127	1154	1190	1222	1252
Spring																		
	March	916	942	967	968	979	980	985	998	1010	1030	1054	1087	1110	1133	1166	1194	1221
	April	814	836	854	855	863	863	865	876	884	900	920	949	968	986	1014	1037	1058
	May	709	727	741	740	746	745	746	755	763	777	795	821	838	854	879	899	919
Summer																		
	June	736	753	766	766	772	771	773	783	791	806	824	852	870	887	912	934	954
	July	720	736	748	747	753	751	753	762	770	784	802	828	845	861	886	907	926
	August	739	754	765	763	769	766	767	775	782	797	815	844	861	877	903	925	944
Fall																		
	September	736	755	769	770	778	777	779	789	797	813	833	864	882	901	929	952	973
	October	745	767	785	787	796	797	800	812	822	838	859	889	908	928	956	980	1002
	November	764	792	814	818	828	830	833	845	855	872	894	925	945	966	995	1020	1044
Actual system peaks (MW)		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Winter																		
	December	1070	1109	1141	1145	1158	1159	1168	1188	1206	1233	1265	1308	1340	1373	1416	1454	1492
	January	1014	1050	1080	1083	1095	1096	1104	1122	1138	1162	1192	1233	1262	1292	1331	1367	1401
	February	1021	1055	1084	1087	1098	1099	1107	1125	1141	1165	1195	1237	1267	1297	1337	1373	1408
Spring																		
	March	1042	1071	1099	1101	1113	1114	1120	1134	1148	1171	1198	1236	1262	1289	1325	1358	1389
	April	980	1006	1027	1028	1038	1038	1041	1053	1064	1083	1107	1142	1164	1187	1219	1247	1273
	May	819	840	856	856	863	861	863	873	882	898	918	949	968	987	1016	1040	1062
Summer																		
	June	798	816	830	830	837	836	838	848	858	874	894	924	943	962	989	1013	1035
	July	778	795	809	808	814	812	814	824	832	848	867	895	913	931	958	980	1001
	August	820	836	849	846	852	849	850	860	868	884	904	936	954	973	1002	1025	1047
Fall																		
	September	828	849	866	866	875	874	877	888	897	915	937	972	993	1013	1045	1071	1095
	October	861	886	907	910	920	921	925	938	950	969	993	1028	1050	1073	1105	1133	1159
	November	840	870	895	899	910	912	916	928	940	959	982	1016	1039	1061	1094	1121	1147

Table 21 -- High growth scenario

GDP by Sector (constant prices of 1996, mln Dram)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	*Growth rate*
Total produced GDP	**787**	**806**	**847**	**863**	**901**	**932**	**972**	**1017**	**1070**	**1120**	**1183**	**1240**	**1310**	**1381**	**1478**	**1604**	**1720**	***5.0%***
Industry	168	175	189	201	213	226	240	255	271	288	305	324	344	366	388	412	438	***6.2%***
Construction	65	64	67	68	74	76	79	88	91	95	101	105	113	119	140	156	160	***5.8%***
Agriculture	246	244	251	250	256	258	263	265	274	278	287	293	303	312	323	350	374	***2.6%***
Total services	229	240	244	244	246	250	257	263	273	282	294	305	317	330	344	366	393	***3.4%***
Transport and communications	56	56	59	59	61	62	65	68	71	74	78	81	85	88	94	101	107	***4.2%***
Trade	79	83	84	80	83	84	88	91	97	104	113	119	128	135	144	156	169	***4.9%***
Public Utility Services	34	32	34	33	39	40	41	47	47	51	56	68	72	77	97	111	115	***8.0%***
Total value added	708	722	751	762	789	811	839	870	908	943	988	1027	1076	1127	1195	1284	1365	***4.2%***
Net Indirect Taxes	78	84	96	101	112	121	133	147	162	177	196	213	233	254	283	321	355	***9.9%***
Total sales of electric energy (GWh)																		
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	***Growth rate***
Residential	1475	1521	1641	1706	1759	1816	1848	1876	1917	1953	1984	2015	2042	2073	2124	2201	2287	***2.8%***
Industry	748	759	793	817	842	867	893	920	947	976	1005	1035	1066	1098	1131	1165	1200	***3.0%***
Budget Organizations	229	250	279	279	285	288	295	302	311	319	329	338	350	361	378	402	422	***3.9%***
Irrigation	456	451	447	442	438	434	429	425	421	417	412	408	404	400	396	392	388	***-1.0%***
Utility services	300	290	303	292	340	346	356	402	405	434	479	572	611	644	807	921	953	***7.5%***
Transportation	191	192	202	201	211	214	224	233	243	253	267	276	290	302	323	345	366	***4.1%***
Other customers	200	206	207	208	207	210	215	218	226	234	242	251	260	271	280	298	321	***3.0%***
Total Domestic consumption	***3600***	***3670***	***3873***	***3945***	***4082***	***4175***	***4259***	***4376***	***4470***	***4584***	***4719***	***4896***	***5023***	***5149***	***5440***	***5724***	***5937***	3.2%
Net export	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	234	***0.0%***
Total supply from the system	**3833**	**3904**	**4107**	**4178**	**4315**	**4409**	**4493**	**4610**	**4704**	**4818**	**4953**	**5130**	**5256**	**5383**	**5673**	**5958**	**6171**	
Net generation (GWh)	**5279**	**5442**	**5588**	**5613**	**5725**	**5774**	**5810**	**5963**	**6086**	**6235**	**6411**	**6642**	**6807**	**6972**	**7352**	**7723**	**8002**	
Gross generation (GWh)	**5676**	**5852**	**6008**	**6036**	**6156**	**6209**	**6247**	**6412**	**6544**	**6704**	**6893**	**7142**	**7319**	**7497**	**7905**	**8304**	**8604**	

Table 21 (continued from previous page) -- High growth scenario

Regular system peaks (MW)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Winter																	
December	944	980	1012	1019	1040	1051	1066	1101	1134	1170	1212	1262	1303	1345	1414	1486	1544
January	922	957	988	994	1015	1025	1039	1073	1103	1138	1177	1225	1264	1304	1371	1441	1495
February	908	940	970	975	995	1005	1019	1052	1081	1115	1154	1202	1240	1279	1347	1415	1468
Spring																	
March	916	944	972	976	997	1006	1014	1041	1063	1090	1121	1160	1190	1220	1286	1351	1402
April	814	838	859	862	878	885	890	913	930	952	977	1011	1035	1059	1114	1169	1209
May	709	728	745	747	760	765	769	789	805	825	848	879	900	922	972	1020	1056
Summer																	
June	736	754	770	772	786	791	795	817	833	854	878	910	933	956	1007	1055	1090
July	720	737	752	753	766	771	775	795	811	830	854	885	907	929	978	1025	1058
August	739	755	770	770	784	787	791	812	827	847	871	905	927	949	1004	1054	1088
Fall																	
September	736	756	774	777	794	800	805	827	844	865	891	926	950	974	1032	1086	1125
October	745	768	789	794	812	820	826	849	867	890	916	951	975	1000	1056	1111	1152
November	764	794	820	826	845	855	861	885	905	928	955	991	1017	1042	1102	1162	1209
Actual system peaks (MW)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Winter																	
December	1070	1111	1147	1155	1179	1191	1209	1249	1285	1327	1374	1431	1478	1525	1604	1685	1751
January	1014	1052	1086	1093	1115	1126	1142	1179	1212	1250	1294	1347	1389	1433	1507	1583	1643
February	1021	1057	1090	1096	1119	1129	1145	1182	1215	1253	1297	1351	1394	1438	1514	1591	1650
Spring																	
March	1042	1073	1105	1110	1133	1144	1153	1183	1209	1239	1275	1319	1353	1387	1462	1536	1594
April	980	1008	1033	1037	1057	1065	1071	1098	1119	1145	1176	1216	1245	1274	1341	1406	1454
May	819	842	861	863	879	885	889	913	931	953	980	1016	1041	1066	1124	1180	1220
Summer																	
June	798	818	835	837	852	857	862	885	903	925	951	987	1011	1036	1092	1144	1182
July	778	797	813	814	828	833	838	860	876	898	923	957	980	1004	1057	1108	1144
August	819	838	854	854	869	873	877	901	917	939	966	1003	1028	1053	1113	1169	1207
Fall																	
September	828	850	871	874	893	900	905	931	949	974	1002	1042	1069	1096	1161	1222	1265
October	861	888	912	918	938	948	954	981	1002	1028	1059	1099	1127	1156	1221	1284	1331
November	840	872	901	908	929	940	946	973	994	1020	1050	1089	1117	1145	1211	1277	1328

Table 22 – ERC Load Growth Estimates

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

ERC initial forecast: Peak Load																		
High case*		1069	1092	1117	1159	1208	1267	1321	1368	1415	1457	1508	1552					
Load factor for high case		0.6719	0.7078	0.7135	0.7192	0.7220	0.7248	0.7277	0.7305	0.7334	0.7363	0.7391	0.7420					
Load factor increment		0	0.0358	0.0057	0.0057	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028					
ERC initial forecast: Gross generation																		
High case		6293	6771	6984	7301	7641	8044	8419	8758	9091	9396	9767	10087					
Low case		6234	6583	6818	7095	7402	7569	7730	7924	8084	8209	8233	8260					
ERC updated forecast: Peak Load																		
High case	MW	1070	1070	1070	1070	1112	1155	1200	1247	1295	1346	1399	1453	1517	1583	1653	1725	1801
Low case	MW	1070	1070	1070	1070	1070	1093	1116	1139	1163	1188	1213	1239	1271	1304	1338	1373	1408
ERC updated forecast: Gross Generation																		
High case	GWh	5716	5716	5716	5716	5966	6228	6500	6785	7082	7393	7716	8054	8407	8775	9160	9561	9980
Low case	GWh	5716	5716	5716	5716	5716	5864	6016	6172	6332	6496	6664	6836	7013	7195	7381	7573	7769
Hagler Bailly forecast: Peak Load																		
High case	MW	1070	1111	1147	1155	1179	1191	1209	1249	1285	1327	1374	1431	1478	1525	1604	1685	1751
Medium case	MW	1070	1109	1141	1145	1158	1159	1168	1188	1206	1233	1265	1308	1340	1373	1416	1454	1492
Low case	MW	1070	1102	1126	1120	1127	1123	1124	1128	1132	1157	1186	1229	1258	1282	1320	1342	1352
Hagler Bailly forecast: Gross Generation																		
High case	GWh	5676	5852	6008	6036	6156	6209	6247	6412	6544	6704	6893	7142	7319	7497	7905	8304	8604
Medium case	GWh	5676	5840	5974	5982	6042	6042	6060	6136	6203	6318	6462	6674	6811	6948	7146	7315	7475
Low case	GWh	5676	5825	5943	5896	5934	5902	5878	5872	5860	5981	6112	6323	6451	6543	6723	6802	6816

*) Data on maximum load for low growth scenario are nor presented in initial forecast